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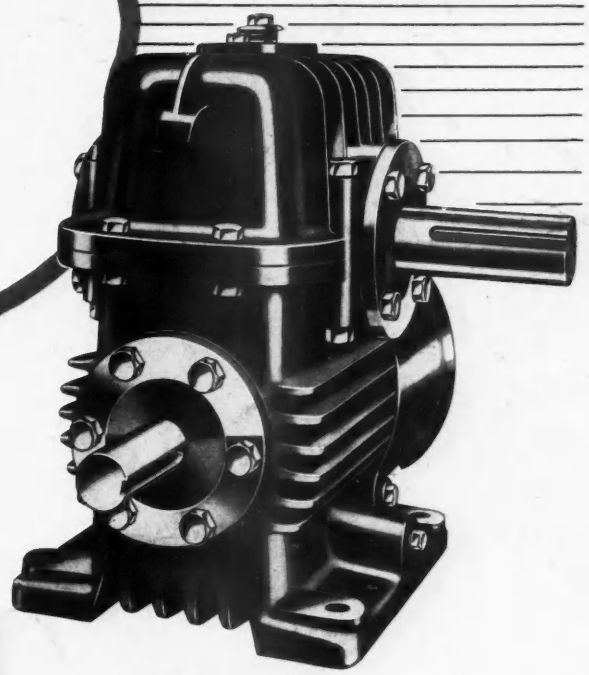

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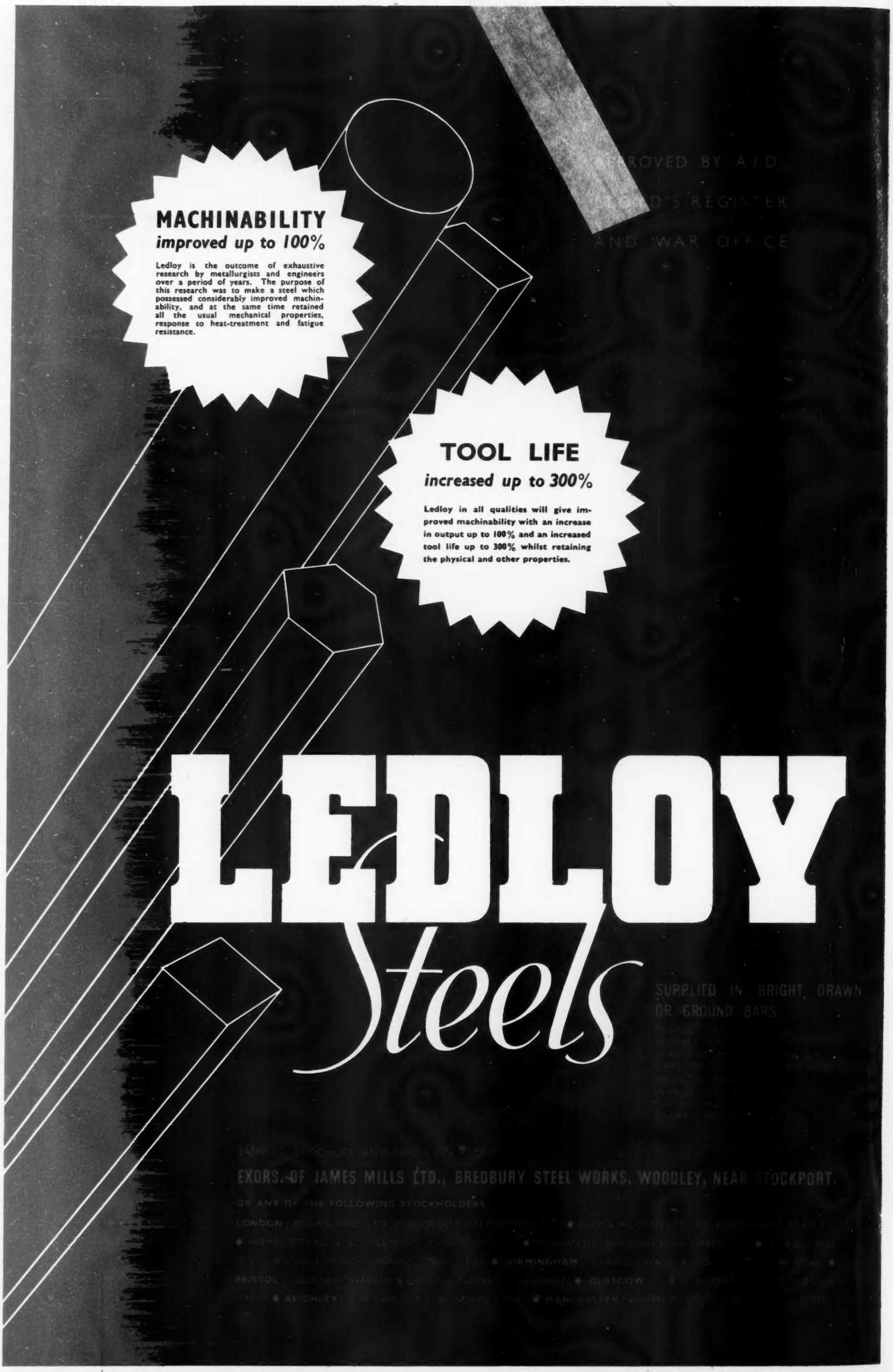
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War Contracts

CERTAIN persons purporting to have special facilities for approaching the Ministry of Supply, and obtaining contracts, are offering their services to smaller firms, particularly as intermediaries on a commission or subscription basis. The Ministry of Supply again desires, in the public interest, and in the interest of these firms, to state than anyone wishing to be considered for Ministry contracts is free to apply directly to the Ministry or to the area officers of the Ministry, and that all such applications are dealt with on their merits. There should, therefore, be no necessity to employ intermediaries who, in return for a financial consideration, represent themselves as being able to influence contracts. The Ministry's aim is to make as full use of small firms as possible consistently with the efficiency and speed of production essential at this time in the national interest, but it is considered that small firms usually would be more useful as sub-contractors to main contractors, since it is not possible for many of the smaller firms to undertake complete manufacture of the various munitions which are required. Groups of small firms may usefully be ranged under a parent firm to form units large enough to undertake complete contracts. Several such groups of firms have indeed been formed. To assist firms, and particularly smaller firms not now engaged in munitions production, the Ministry some time ago arranged samples of munitions stores at convenient centres throughout the country. Officers of the Ministry are in attendance at these centres and firms wishing to inspect the stores and to be advised in respect of their manufacture, are free to make appointments directly without the intervention of any intermediaries.

Anglo-French Industrial Pool

ON January 18th, Monsieur Raoul Dautry, French Minister of Armament, and Mr. Leslie Burgin, British Minister of Supply, jointly outlined for the Press the progress made in Anglo-French collaboration in industrial production. It will be recalled that Monsieur Dautry arrived in this country recently for consultations with Mr. Burgin. The British Minister stated that they were trying to make a pool of the manufacturing resources of the two Empires, not only in raw materials but in actual manufacturing capacities. They hoped to be able to push that idea so far that it might be possible to have machine tools crossing from one side of the Channel to the other and back again, according to the needs of either country. Monsieur Dautry, recalling his previous visits as a railway engineer, said England did not change. It was always in the same spirit and with the same countenance that she faced difficult times. The work already accomplished was enormous. The English factories, as he had been able to judge for himself during his visit, were turning out armaments at top speed. The co-operation of the two nations multiplied their strength, and never, even during the last month of the war of 1914–18, had it been what it was to-day. French and British Ministers, members of the executive committees, scientists, engineers, and manufacturers had been working closely together. France and England had pooled their military forces, their economic wealth, and their financial means by agreements drawn up by their Prime Ministers and financial ministers, and now Mr. Burgin and he had combined their science laboratories, technical resources, machines, and labour. Replying to questions, Monsieur Dautry said that, of course, before the war France and Britain had different types of guns, but under the pooling agreement new arms would be of the same type. The two countries were also tackling the problem of a common policy in exports.

Inventions in War Time

IN the House of Lords on Thursday, January 18th, Lord Strabolgi asked the Government whether there was a central organisation or clearing house for the examination and test of inventions and improvements which might be of use for the successful prosecution of the present war; what method of co-ordination between the scientific departments of the three fighting services and of the Ministry of Supply existed; and what were the means of liaison between His Majesty's Government and the Government of the French Republic for the mutual exchange of scientific knowledge of importance to their joint war efforts. He admitted that the Advisory Council of Scientific Research and Technical Development which had just been appointed by the Minister of Supply was as strong a team of scientists as could be gathered together in this or any other country. When new weapons, such as the magnetic mine, were disclosed we must be able to mobilise the best scientific brains not only of this country but of the world to provide counter-measures. All scientists except those in Germany must be on our side because the scientific mind with its love of truth was utterly opposed to the make-believe and lies of Nazism. Lord Chatfield, Minister for the Co-ordination of Defence, replied that he had always appreciated the immense importance of scientific research to the Services. There were no fewer than eight research laboratories under the Department of Scientific and Industrial Research alone. The scientific talent of this country was fully mobilised and ran into a very large number of scientists, to be numbered rather in thousands than hundreds. There was actually no central organisation or clearing house to deal with this particular aspect of inventions. Each Department had its own organisation. There were joint committees between the Services for dealing with many subjects, such as wireless telegraphy, ordnance, guns, and aeronautics. An invention got into the hands of experts as quickly as possible. The idea of having a central body was considered by the Government not long ago and they came to the conclusion that on balance a central body would hamper rather than hasten matters. Each year the scientific departments of the three fighting Services, the Ministry of Supply, and the Department of Scientific and Industrial Research drew up plans of research to be carried out during the following year. This annual review had resulted in much improvement and stopped work which seemed to be going on for a long time with little chance of reaching finality. When he was at the Admiralty, for instance, work was being carried out on television. It was hoped to be able to see shots falling over the enemy from the bridge of the ship firing them. After the work had gone on for some years a television set was produced but was too large for its purpose. There was nothing that had happened in the war so far—any surprise or partial surprise—which had not been fully resolved with the greatest rapidity by the methods we had at the present time. Referring to the second part of the question, he said a mutual exchange of scientific knowledge had been concerted, and was already in progress, between the British and French Governments before the outbreak of war. Nevertheless an extension of the present liaison was under consideration. With regard to rewarding inventors, he thought that it was likely that a Commission of Awards to Inventors would be created, as in the last war.

Destruction of Floating Mines

A WRITTEN answer by the Parliamentary Secretary to the Admiralty to a question by Sir Robert Gower is to the effect that special ships are being fitted out for blowing up floating mines. In *The Times* of January 20th, the naval correspondent points out that ordinary submarine mines are frequently found floating at sea, their moorings having parted either from heavy weather or when broken by a sweep wire. The quickest way of disposing of such a mine is by rifle fire. The mine is usually punctured, fills with water, and sinks, though if the bullet should chance to hit one of the "horns," the mine may be exploded. The latter event, however, is rare; most mines are sunk. Nearly all such mines lying waterlogged on the bottom are harmless. But one in fifty, perhaps, retains the capacity to explode if a "horn" is bent; and if a fisherman dredges up one of them in his trawl the result is disastrous. Sir Robert Gower therefore asked the Admiralty to ensure that all mines found floating should be blown up instead of merely being punctured and sunk. *The Times* points out that this procedure is not always practicable. In the "mine clearance" operations after the last war it was commonly done by means of a "destructor sweep," by which floating mines were gathered together in bunches and blown up. But those operations were leisurely, and the number of sweeping craft was ample; neither condition obtains in war-time. Nevertheless the Admiralty are fitting a number of patrol craft with "destructor sweeps," and when circumstances permit they are to be employed in the areas in which floating mines are thickest. But it will still often be necessary to sink floating mines as before. The danger of leaving them floating pending the arrival of a "destructor sweep" which may not be available, is incomparably greater than the occasional danger to trawlers of a mine which is still "live" lying on the bottom.

Road Research Board Report

THE report of the Road Research Board for the year ending on March 31st, 1939, has been issued by the Department of Scientific and Industrial Research. It emphasises the close relation between laboratory research and full-scale tests on public roads and gives details of numerous trials which accompanied or followed laboratory investigations. Laboratory tests on the use of acid to reduce the slipperiness of smooth concrete surfaces, for example, were continued on a full scale, and it was shown that the method was both practicable and cheap. An investigation is in progress on the treatment of ice-bound concrete surfaces with chemicals so as to thaw the ice without damaging the concrete, and durability tests on bituminous binders are being compared with the road performance of surface dressings and thin carpets containing these binders. Full-scale trials are in progress on tar-rubber binders designed in the laboratory for surface dressings and for thin surfacings, and a series of carpets containing asphaltic binders has been laid on the Colnbrook by-pass with a view to relating their physical properties with road behaviour. Work involving extensive practical trials is proceeding co-operation with the Timber Development Association with the aim of improving the skidding resistance of wood block surfacings, and another research has led to practical trials of an improved cast-iron surfacing, whereby it has been possible to increase the sideway force coefficient from about 0·25 to 0·45. During the year it was found necessary to enlarge the laboratory site and a further 16 acres of land have been purchased.

Loss of Two Destroyers

ON Sunday, January 21st, it was announced with regret by the Secretary of the Admiralty that the flotilla leader H.M.S. "Grenville" had been sunk either by mine or torpedo in the North Sea. One hundred and eighteen officers and men have been safely landed at a port on the east coast of England, but it is feared that 73 men are missing and must be presumed to have lost their lives, while it is known that a further eight men were killed. The "Grenville" was a flotilla leader of Admiralty design which was built at the Scotstoun yard of Yarrow and Company, Ltd. She was begun on September 29th, 1934, launched on August 15th, 1935, and completed on July 1st, 1936. She had a standard displacement of 1485 tons, and her principal dimensions were, length 319ft. between perpendiculars, 327ft. on the water line, beam 34ft. 6in., mean depth 8ft. 8in. Her armament comprised five 4·7in. guns, and seven smaller guns, and she carried eight 21in. torpedo tubes arranged in quadruple. The propelling machinery consisted of Parsons' geared turbines taking steam from four Admiralty type three drum boilers of the side-fired pattern, designed for burning oil-fuel, of which about 470 tons was carried. Steam was generated at a working pressure of 300 lb. per square inch, with a high degree of superheat, and the total designed output of the turbines was about 38,000 S.H.P., corresponding to a speed of 36 knots. The "Grenville" embodied in her construction several unusual features and was among the first of the naval vessels to be equipped with side-fired boilers, which have been adopted with success in many mercantile vessels fitted with Yarrow boilers. The cost of the "Grenville" is given as £335,928. Her Commander was Captain G. E. Creasy, M.V.O., who succeeded Captain C. M. Blackman in command of the 1st Destroyer Flotilla in H.M.S. "Grenville" in June, 1938. It was Captain Creasy's first command as Captain, and before taking this command he was Assistant Director of Plans at the Admiralty for two years. We learn at the time of going to press that H.M.S. "Exmouth" has been sunk in the North Sea. It is feared that her complement of 175 officers and ratings have been lost. H.M.S. "Exmouth" was a flotilla leader of 1475 tons.

The Engineers' Guild

AT a meeting of the Engineers' Guild on December 14th, four resignations of membership were received, and nine new members, whose applications had been received since the new Constitution became operative on June 1st, 1939, were elected. The membership roll then contained the names of 230 ordinary members. The Council, it was stated, had considered proposals for the maintenance of the Guild during the war, and the course decided on is to keep the present General Council in office ready to resume affairs where they are left off, and to entrust all business meantime to a small executive committee consisting of the Chairman, Secretary, and Treasurer and one other Member of Council, and it was agreed that Mr. T. M. Megaw should serve in this capacity. In order that annual elections and general meetings may be dispensed with, a temporary amendment of the Constitution was found to be necessary. This and the other formal resolutions of the Council in which the arrangements are embodied were set out in full and circulated to the members for their comments and have now been approved by 71 votes to 2. The affairs of the Guild are now, therefore, in the hands of a small executive committee, not necessarily for the duration of the war, but until the Council, which can be called together at any time, may decide otherwise, and members are invited to bring to the notice of the Committee any affairs which may seem to call for the Guild's attention. It is hoped that by these means the Guild will survive the war and be able to resume activity after it, or if need be, earlier.

E

Drying Out Flooded Electrical Machinery

FOLLOWING the flooding of the Ontario power generating station (a 180,000 H.P. development of the Hydro Electric Power Commission of Ontario, situated on the Niagara River at Niagara Falls, Ontario), on January 26th, 1938, the Commission's staff was faced with the problem of returning the plant to service with a minimum of delay and expense consistent with the Commission's standard of maintenance. The conditions which had to be met were described in general terms in THE ENGINEER of March 17th, 1939. That article dealt very briefly with certain technical details which were of more than passing interest; the present one deals with a number of these details in a more comprehensive manner.

Two methods of drying the equipment were used successfully at the Ontario power generating station. In both the machine is first washed down with a cleaning solvent and wiped as dry as possible, the hand-taped insulation being removed from the coil ends at the soldered joints to permit the egress of moisture. The machine terminals are then disconnected before the drying operations are begun. The methods employed are referred to as: (1) Hot air and internal heating. (2) Vacuum drying. In the first method, drying is accomplished by producing the evaporation of moisture by the circulation of hot air through the windings, the hot air supply being obtained from a combination fan and heater installation. Obviously, one of the first steps to be considered is the selection of the proper size of heater and fan for any given machine.

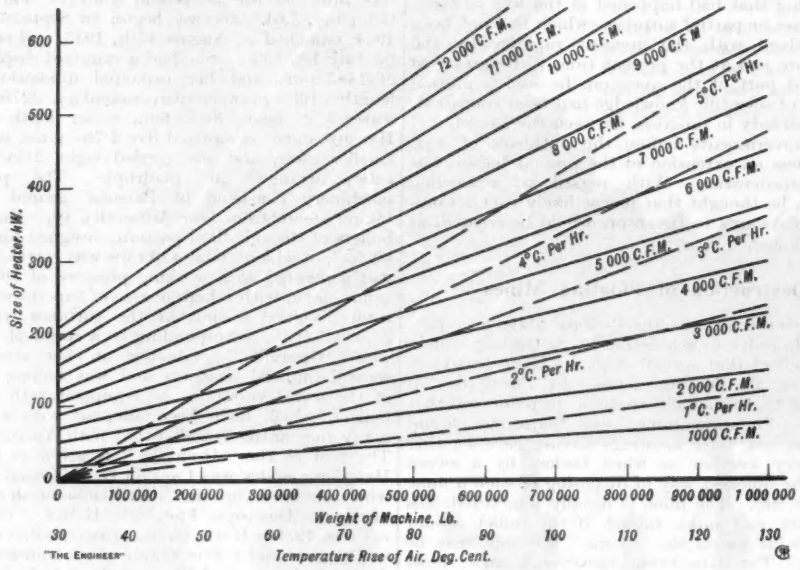


FIG. 1—SELECTION CHART FOR FAN AND HEATER SIZE

The selection of the proper size of unit is greatly facilitated by the use of the chart shown in Fig. 1, which has been prepared from a series of calculations and which gives the fan and heater size required to raise the temperature of the air to the desired value at various heating rates and for different weights of machines. This chart is used as follows: (1) Determine the weight of the machine to be dried; the total weight of iron and copper will be close enough, as a safety factor has been provided in the curves. (2) Decide upon the heating rate to be used; generally speaking, a low rate will be selected for the large machines to prevent mechanical stresses through too rapid heating. For smaller machines a somewhat higher rate may be safely used. Rates in excess of 5 deg. Cent. per hour are not recommended. (3) Having determined the values for (1) and (2) above, the size of the heater may be read directly from the chart by finding the point of intersection of a vertical line drawn through the weight of the machine as an abscissa and the dotted line corresponding to the rate of heating selected, and from this point following a horizontal line to the left to the heater size indicated. (4) Select the air temperature rise required. This should be done as follows:—Assume the maximum allowable temperature of the winding to be 25 to 30 deg. Cent. below the rated maximum for the insulation, as this should be a safe and satisfactory value for prolonged application of heat. To this figure add 35 deg. Cent. which will offset the heat losses and produce a reasonable heating rate. The figure so obtained will correspond to the required temperature rise of the air. Using the heater size as determined in (3), find the point of intersection of a horizontal line through this point with the vertical line through the temperature rise required, and by means of interpolation between the fan capacity curves shown, the required quantity of air in cubic feet per minute will be indicated. A fan capacity of about 10 per cent. in excess of this value should be used to give ease of temperature regulation.

TYPE OF HEATER

Because of the high temperature required for rapid drying, and for economic reasons, an electric element is practically a necessity for heating, and as fairly large heaters will generally be required they will probably have to be built specially for the job.

A satisfactory type of electric heater, according to the engineers of the Operating Department of the Hydro Electric Power Commission, may be constructed, using $\frac{1}{2}$in. by $\frac{1}{16}$in. band iron for the element which should not be worked at more than about 200 deg. Cent. in order to remain within the safe temperature limits for the iron. As the resistance of this iron is about ·0091 ohm. per foot at 200 deg. Cent., the total length of iron required is readily calculated for any particular size of heater at a given voltage from the formula:—

$$\text{Watts} = V^2/R$$

As the length of iron will be considerable, conservation of space is a factor and it will be found that some saving will be made by winding the iron in coils upon a 2in. or 2$\frac{1}{2}$in. mandrel and supporting the coils on an iron pipe framework by means of strain insulators. A 150 kW, 550 volt heater, constructed on these lines is shown in Fig. 5, page 88.

In order to reduce heat losses and concentrate the heating, all windings and iron of the machine should be completely enclosed. A housing of 2in. by 4in. wood studding with $\frac{3}{8}$in. sheet insulating board used to form an interior lining for the studding, thereby reducing wall air friction to a minimum, makes an ideal enclosure. Economy permitting, rock wool insulation should be applied to the upper half of the roof of the house, which may be held in place between the studs by means of wire netting. The lower half of the house may be wrapped with asbestos paper, with an air space between the paper and the insulating board. Since the materials used in the construction of such an enclosure will have a fairly high salvage value at the termination of the job, and as the heat losses will be kept to a minimum, the additional insulation is recommended.

The inlet to the enclosure should be as near the base of the machine as possible with ventilation openings provided in the opposite wall near the base and in the roof corner diagonally opposite to the inlet opening. Doors, preferably sliding, must be provided for these openings so that the correct air flow may be maintained and the inlet air temperatures regulated. An entrance door to the enclosure should also be provided for purposes of inspection. Fig. 6, page 88, shows enclosures of this type built over some 9000 kW. machines at the Ontario power generating station.

Some means must be provided for measuring temperatures at various points on the winding surface, and if such indicators are not built into the machine the easiest method of obtaining the required readings is by attaching thermo-couples to the winding surface by means of putty. Couples should be situated at the ends of the coils and should be placed at points which will permit obtaining a complete survey of the machine temperature. This is necessary since the hottest point and temperature spread will govern the drying rate of the machine. It has been found by experience that the drying rate is materially increased when the whole machine is dried at a uniform temperature.

A thermal relay which will operate to shut down the fan and heater should be installed in the roof of the drying enclosure and at some point close to the heater. An air flow relay should also be used in the air stream to shut off the heater in the event of the accidental stoppage of the fan. These precautions are necessary to safeguard the machine against excessive temperatures which might permanently damage the windings.

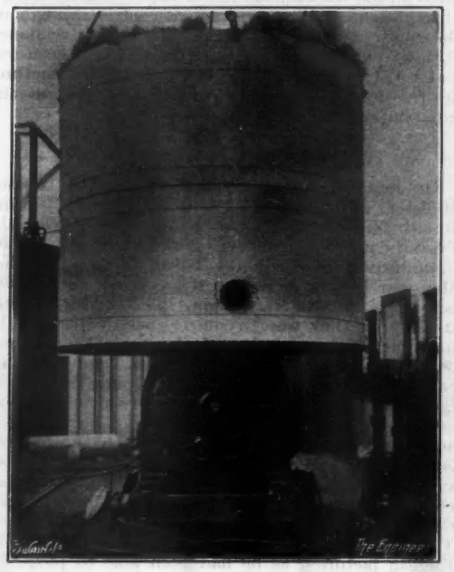


FIG. 2—VACUUM TANK FOR SMALL MACHINES

OPERATION OF EQUIPMENT

In this method of drying rotating machinery, four operational stages are necessary:—

(1) The initial heating-up period which is carried out with the machine at rest must be performed carefully to avoid cracking the insulation; this requires the selection of the proper size of fan and heater to produce a safe heating rate. During this period, the machine is heated uniformly but as the machine temperature approaches the desired maximum, it will be found necessary to vary the ventilation opening sizes. It may be found that the fan inlet must be partially blocked or that a new ventilation opening is required.

(2) When it is deemed that the insulation is sufficiently firm to withstand mechanical stresses set up from centrifugal force, the rotor of the machine should be rotated at about half speed. The only means of determining whether or not the insulation will withstand the stresses of rotation is by inspection. Insulation resistance tests should be made daily to follow the progress and effect of the drying. However, care must be taken to choose a suitable megger, one which will not produce a voltage high enough to damage weak insulation.

(3) A synchronous machine, such as an alternator, should be stopped periodically and the field insulation tested. When the field resistance reaches about 1000 ohms. per volt of maximum field voltage, the stator windings should be short-circuited at the terminals and a weak field built

up, preferably using a separate exciter as a direct current supply. This produces internal heating of the copper and tends to drive the moisture outwards to the coil surfaces and to the open ends of the coils. At this stage it becomes necessary to cut off the exterior heat and use the fan only, as otherwise excessive temperatures will result. The machine temperature is then controlled by the amount of field excitation and cold air flow. In all probability it will be found that the bottom sections of the machine will be colder than the top, but this may be corrected by installing two or three small electric heaters in the pit under the base of the machine. In the case of an asynchronous machine, such as an induction motor, internal heating should be provided by passing a direct current through the stator winding, using an exciter unit for this purpose since low voltage is required and the amount of current is limited by the maximum permissible insulation temperature.

(4) In the fourth stage the daily megger tests of the insulation should be continued, and periodically, about every three days, a temperature run-down test should be conducted upon the machine. This test consists of cutting off all heat and allowing the machine to cool to approximately 40 deg. Cent.; while the machine is cooling megger insulation tests are made, noting the temperature at which each reading is taken. From these data the characteristic curve of insulation resistance against temperature may be plotted, using a

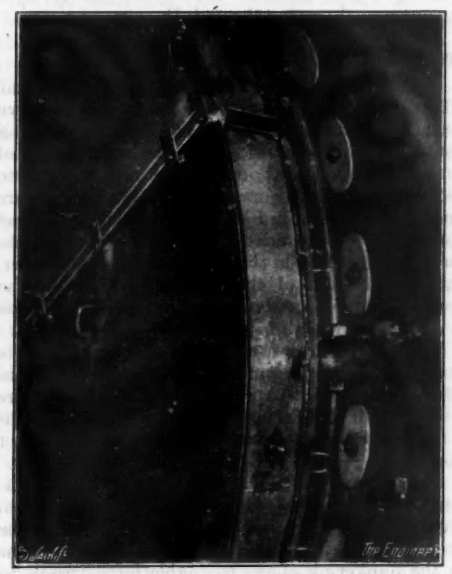


FIG. 3—SEALING OF VENTILATION PORTS AND PLATE SECTORS

logarithmic scale for megger readings and an arithmetic scale for temperatures. When the insulation resistance has reached a constant value, the machine may be considered dry; it remains then only to reinsulate the ends of the coils, apply a high potential test, and place the machine on load.

During the drying operations at the Ontario power generating station, the question was raised as to the possibility of moisture condensing on the windings during the cooling tests; however, it was soon realised that trouble from this source would be highly improbable, except possibly in tropical climates. It is impossible for moisture to form on a machine unless it cools below the dew-point temperature of the surrounding air. Since large amounts of heat are being added to the air while the temperature of the machine is falling to 40 deg. Cent., it is extremely unlikely that very high percentage humidity will be encountered, even during the period of maximum evaporation, and, therefore, there is little or no danger of moisture gathering upon the windings during a "decreasing temperature" test.

VACUUM DRYING METHOD

The hot air and internal heat method previously described is a positive method but it is slow. The vacuum method is a much quicker way in which to dry flooded equipment but, owing to the nature of the apparatus required, it may be a more expensive process.

The method used for large units resolves itself into a problem of economy. The special vacuum tank for a single machine will most likely cost more than an air drying assembly. On the other hand, if the equipment is urgently required or a loss of revenue is involved, it may be more economical to use the vacuum tank and thereby materially shorten the drying time. Where there are a number of similar machines to be dried and their design permits the use of the same vacuum equipment on each of them, it may prove cheaper to dry by means of the vacuum method than by means of hot air alone. Where there are a large number of small machines to be dried and a medium-sized vacuum tank can be constructed at relatively low cost, the vacuum process is unquestionably a cheaper, quicker and more reliable method of dealing with the problem than any other method developed so far.

With the vacuum method the moisture is removed more rapidly because of the increased rate of evaporation at the lower pressure. Further, the moisture is given an added impetus to move outward through the insulation, because of the lower surrounding pressure. These two factors account for the much increased drying rate.

In order to place the machine under vacuum, it is necessary to enclose it in an air-tank. For small machines, large oil drums or water tanks serve the purpose very well. It would be prudent, however, to calculate the stresses to be imposed upon such a tank before applying a vacuum, since some internal bracing might be required. Fig 2 shows a vacuum tank. Machined flanges on the covers are not essential. A very effective seal can be made, using rough flanges and ½in. plain round rubber or ½in. corrugated garden hose as a gasket. A piece of round solid rubber of appropriate diameter should be pulled through the hose to prevent it from cracking when bolted between the flanges. To fill any small cracks, caulking compound covered with a few layers of friction tape and painted with "glyptal" serves very well. The tape is necessary since the caulking compound, when used alone, will be forced through the crack upon the application of a vacuum.

Large machines present a different problem so far as the construction of the tank is concerned. At the Ontario power generating station the machine frame itself was used as part of the vacuum tank. End covers of ½in. boiler plates were made in three segments for ease of handling. As in the case of small vacuum tanks, garden hose was used to seal the edges of these plates. Cast iron oval-shaped discs fitted with 1in. square rubber gaskets were used to cover the ventilation ports—see Fig. 3. Internal bracing was necessary to prevent the plates from buckling under the vacuum—see Fig. 7, page 88. Inasmuch as machines differ in structural details the design of the vacuum tanks must take account of their individual features.

Leak-proof bushings are inserted in the wall of the tank to provide for the installation of thermo-couple and current leads. Two pipe stubs are welded in place, one for the vacuum pump connection, the other for a vacuum control valve which opens to the atmosphere. Since vacuum pumps are not always readily available pieces of equipment, an air compressor may be used and it will serve the purpose very well. The air intake inside the compressor is connected to the vacuum chamber, sucking air from the chamber and discharging it at atmospheric pressure. Provided that the vacuum chamber has been properly sealed, vacua as high as 26in. to 28in. of mercury are easily obtained. A condenser trap must be installed in the suction line to prevent water entering the compressor. Provision should also be made to collect and measure the condensate, so that the hour-by-hour quantity of water removed from the machine may be determined. In Fig. 4

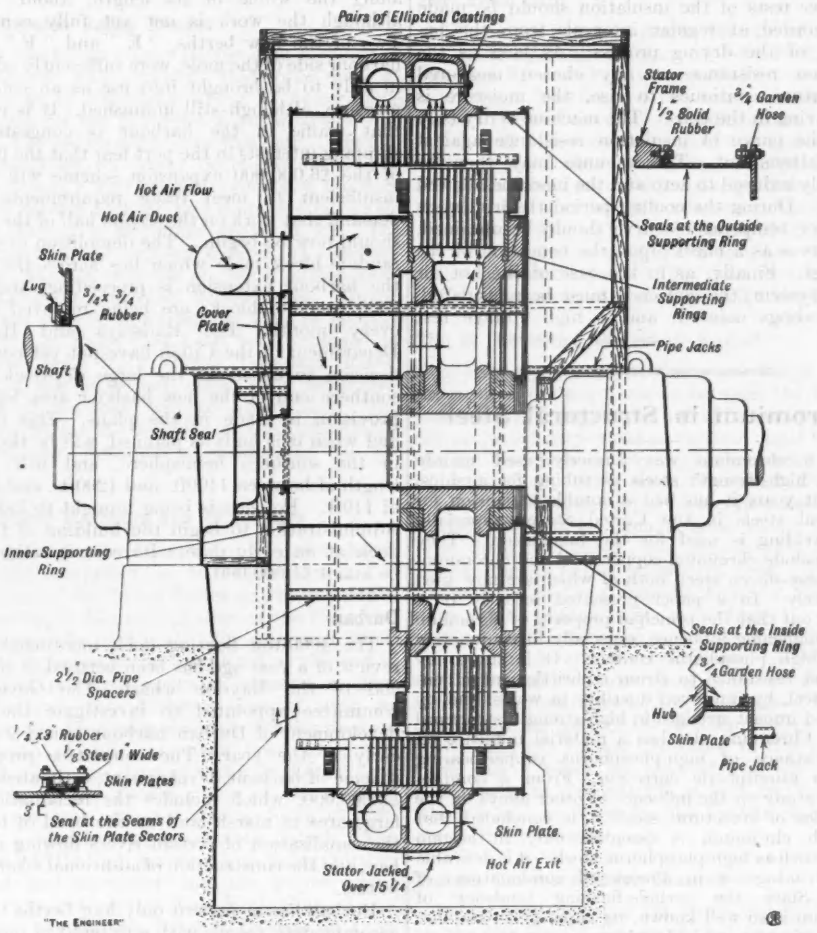


FIG. 4—ARRANGEMENT OF VACUUM CHAMBER AND DRYING ENCLOSURE

and Fig. 8 on page 88 are illustrated the general arrangement and details of a large vacuum chamber and drying enclosure.

Although it requires less heat to evaporate moisture at lower pressures, more of the applied heat will be absorbed per unit of time because of the rapid rate of evaporation. Thus, insulation is necessary to reduce heat losses from the tank. For small tanks this insulation may be provided by binding rock wool around the sides and ends, whereas for large tanks of irregular shapes a frame enclosure built in sections may be quickly and easily assembled over the complete machine. A separate air heater can then be used to heat the enclosure and keep the vacuum tank at a high temperature.

DRYING PROCEDURE

In the process of drying under vacuum, care must be taken not to produce such an evaporation rate that pockets of steam are formed in the insulation. Should this occur, the insulation might easily be ruptured. Before applying any vacuum whatsoever, the machine temperature as a whole should be raised to a value determined by the quantity of insulation used on the windings. The means of obtaining high temperatures and controlling them may be effected in three ways: (1) For small tanks, by placing small electric

heaters inside the tank. (2) For large tanks, by blowing hot air into an air-tight supplementary chamber containing the vacuum tank, much in the same manner as in the hot air drying scheme. (3) By internal heat means. Since the rotor must remain stationary, the armature windings should be connected in series and supplied with direct current from a controlled source. This is by far the best method.

When the whole machine has come to a steady temperature the pumps should be started with the vacuum control valve wide open and the vacuum applied gradually. In building up the vacuum care must be taken to avoid excessive steaming in the coils. A slow rate of evacuation, about 1in. mercury every 15 minutes, is essential in establishing the vacuum. As the vacuum increases the moisture will leave the coils in the form of low pressure steam. The machine temperature may fall as a result of the rapid rate of evaporation and this fall may necessitate an increase in the stator or armature currents. The vacuum should be increased slowly until the maximum possible has been attained. It should be held there until the machine has been thoroughly dried.

Megger tests of the insulation should be made and recorded at regular intervals from the beginning of the drying process. As long as the insulation resistance at any chosen measured temperature continues to rise, the moisture is still moving in the coils. The machine is dry only when the curve of insulation resistance against time flattens out. The vacuum may then be gradually reduced to zero and the machine allowed to cool. During the cooling period the insulation resistance temperature curve should be obtained. This serves as a check upon the condition of the windings. Finally, as in the case of the hot air drying system, the coil ends must be reinsulated, the windings painted, and a high voltage test applied.

Chromium in Structural Steel

WHILE chromium was formerly used mainly in such high-strength steels as tubing for airships, in recent years it has had a notable expansion for structural steels in the United States, especially when welding is used for the fabrication. They alloys include chromium-copper steel and chromium-manganese-silicon steel, both of which are now used extensively. In a paper presented recently it is pointed out that the principal property of chromium is its toughening influence, especially in conjunction with a high phosphorus content. It is shown by increased resistance to strain embrittlement in unkilled steel, by improved ductility in welds, and by increased impact strength in high-strength structural steels. Chromium also has a material influence on the resistance of high-phosphorus copper-bearing steel to atmospheric corrosion. From a comprehensive study on the influence of other alloys on the properties of structural steel, it is concluded that although chromium is essential only in certain types—such as high-phosphorus steels—it is desirable and advantageous in almost all combinations of alloys. Since the carbide-forming tendency of chromium is so well known, its capacity to stabilise oxygen, nitrogen, and phosphorus is apt to be overlooked, but in low-carbon structural steels these secondary characteristics became more prominent. In this way, also, the chromium is definitely a toughening agent. As the carbon content is increased the more generally known hardening effect becomes more evident. As the distribution of chromium between ferrite, carbide, and phosphide changes with the other elements in the steel, similar changes appear in the mechanical properties. In welded steel, chromium tends to prevent the formation of a brittle martensite in the metal adjacent to the weld. While it reduces atmospheric rusting, it has an even more important effect in the fine grain and abrasion-resisting character of the rust scale.

X-RAY INVESTIGATION IN THE STRUCTURE OF MATTER.—At the end of a paper on methods of utilising X-rays industrially, given before the Royal Society of Arts in London by Mr. H. P. Rooksby, he spoke of the contribution that X-ray analysis was making to fundamental ideas of the structure of matter. New conceptions were arising directly out of the recent measurements on lattice distortion and the lower limiting size of crystallites developed in a cold worked metal, and the gradual clarification and development of the picture of the ultimate structure of matter owed much, and would owe still more in the future, to the revealing and searching power of X-rays. Changes in lattice dimensions of a few parts in ten thousand can be measured in this way, not only for purposes of identification but also for the determination of texture. He pointed out that the powdered crystal method usually has to be aided by other means when the precise atomic positions within a structure have to be revealed, but in industry less elaboration generally suffices for the recognition of a substance.

Harbours and Waterways in 1939

No. III

(*Continued from page 56, Jan. 19th*)

AFRICA

South African Harbours

IN our issue of October 27th, 1939, we published an illustrated article describing in some detail recent developments in the principal harbours of the Union, Cape Town, Port Elizabeth, East London, and Durban. In this article we pointed out that up to March, 1938, the total amount expended upon the harbours of the Union amounted to £18,300,000 after deducting amounts spent on works which have become obsolete, &c.

Cape Town

The construction of Cape Town's new harbour in Table Bay is proceeding rapidly. The new Eastern Mole, or outer breakwater, is now closed along the whole of its length, about 7000ft., although the work is not yet fully completed. Two of the new berths, "E" and "F" on the harbour side of the mole, were sufficiently advanced in July to be brought into use as an emergency measure, although still unfinished. It is reported that traffic in the harbour is congested and shipping interests in the port fear that the first half of the £6,000,000 expansion scheme will still be insufficient to meet trade requirements. They demand that work on the second half of the scheme should now be begun. The demolition of the old-random-block mole which lies across the site of the harbour extension is proceeding, and about 2500 concrete blocks are being removed from it every month. The Railways and Harbours Department of the Union have not yet come to a decision to construct the large dry-dock at the southern end of the new harbour area for which provision is made in the plans. This dock, if and when it is built as planned, will be the largest in the southern hemisphere, and will have a length of between 1100ft. and 1200ft., and a width of 110ft. Pressure is being brought to induce the Administration to begin the building of the dry-dock at an early date. Its cost is estimated to be about £1,000,000.

Durban

The 4000-ton floating dock mentioned in our review of a year ago has been berthed at the inner end of the Maydon wharf. The Government committee appointed to investigate the future development of Durban harbour issued its report early in the year. The committee proposes a scheme of harbour development, estimated to cost £3,000,000, which includes the reclamation of a large area of marsh land at the head of the bay, the canalisation of certain rivers flowing into the bay, and the construction of additional wharves and jetties.

Durban has at present only four berths that can accommodate vessels with a draught of more than 30ft., but when the T jetty on the east side of the bay is completed and the berths alongside the existing wharves are deepened, this number will be considerably increased.

The entrance to Durban harbour between the north pierhead and the south breakwater has never been entirely satisfactory, and at times vessels have been delayed in making the entrance in heavy weather. The width of the entrance is at present 600ft. only, but a start has recently been made to remove the cant at the outer end of the north pier with a view to improving the entrance channel. The estimates of the Railway and Harbours Administration for the year 1939–40 include £500,000 to be expended on the harbour improvements at Durban.

East London

The extension of the south breakwater at East London is still in progress. When completed in accordance with the present authorisation the breakwater, which is a composite structure of random concrete blocks with mass concrete superstructure, will have a length of 3400ft. Additional wharfage is also under construction at East London.

Beira

The fourth of the deep-water berths in the harbour at Beira alongside the openwork wharf structure, the construction of which was begun in April, 1937, was brought into use early in the year. The construction of the fifth berth began in 1938, and was due to be completed by the contractors, Pauling and Co., Ltd., at the end of 1939. One of the new transit sheds on the wharves has been completed and another is under construction.

Among the new works recently undertaken by Beira Works, Ltd., for the improvement of the port is the cutting of a new channel across the Portella Bar and the deepening of the existing entrance channels. The expenditure on the contract works due for completion at the end of 1939 has amounted to about £830,000.

Italian East Africa

The new Red Sea port which is being made by the Italian Government at Assab, work on which began in January, 1938, is expected, according to an Italian report, to be substantially completed by April, 1941. The accommodation which will then be available includes wharfage 1200 m. long with a depth of water from 9 to 10 m. and 700 m. of quayage for small vessels. Two moles are being constructed to afford protection to the berthing area. The port is to be linked with Addis Abbaba by a new road passing through Dessié.

French Ports in Africa

In spite of France's preoccupation with war affairs in Europe there does not seem to have been any serious interference with the carrying out of harbour extensions on the west coast of Africa, where naval necessities are taken into account as well as commercial needs. Plans are under consideration for large extensions of the harbour at Casablanca to provide accommodation for the larger ships in the French navy. Moreover, the development of the phosphate trade of the port necessitates an almost continuous construction of additional wharves and equipment in the port.

Work on the new harbour at Pointe-Noire in the French Congo is proceeding. The harbour was officially opened in April, although the works are still far from completion. The port is the terminus of the railway line from Brazzaville on the River Congo.

At Dakar in French West Africa, the construction of an outer basin is now in progress to give shelter to ships of large tonnage. The deepening of the petroleum basin and the berths at the bunkering quays to enable large vessels to lie alongside at low-water has already been completed. Large extensions of the transit sheds in the port are being made, and the equipment of electric cranes is being extended.

Work is also in progress at Conakry in French Guinea and at Abidjan on the Ivory Coast, where works were begun early in 1937 to develop a deep lagoon as a port by the formation of an approach channel through the coastal belt of sand and the construction of training jetties.

The French Colonial Administration are also carrying out important extensions at Djibouti, the port of French Somaliland and the sea-terminal of the railway at Addis Abbaba. The first of the new deep-water quays in the harbour has been completed; another quay and the extension of the breakwater are in progress.

THE EAST

Burma

The Brooking Street wharf at Rangoon, which has been constructed at a cost of £400,000 and provides deep water accommodation for ocean liners was inaugurated by the Governor of Burma, Sir Archibald Cochrane, on March 31st. Sir Alexander Gibb and Partners were the engineers responsible for the construction of the wharf, which was built by direct labour.

Indo-China

Early in the year, the French Government were said to be considering the provision of more adequate port accommodation for ships of large tonnage on the coasts of Indo-China and Saigon. Preliminary plans have been prepared for the construction of a commercial port in Camranh Bay, north-east of Saigon. A preliminary expenditure of 20 million francs on the construction of a maritime station, wharves, and oil-storage equipment has been sanctioned and will

be provided for out of a credit of 300 million francs already allocated for the defence of Indo-China.

Singapore

The First Lord of the Admiralty, in his explanatory statement on the Navy Estimates for 1939 issued in February, said that at the Singapore naval base work is being pressed forward in connection with the completion of the north wharf and store-basin walls; and, in particular, the erection of accommodation for the crews of vessels refitting there. A second electric generating station is being built at the naval base.

Japan

It is proposed to expend 32 million yen on the improvement of the port of Osaka. It is also reported from Japan that Dairen harbour is to be doubled in size at an estimated cost of £5,000,000. The development plan envisages the extension of the breakwater by 6560ft., the construction of new and the extension of old piers and the reclamation of 2600 acres of land.

AMERICA

United States Naval Defences

Early in January, a naval board, instructed by Congress to report on national defence, presented a report in which the strengthening of the national defence system was urged upon Congress. The expansion of existing air and submarine bases, the construction of new ones, and the extension of the present continental defence limits deeper into the Caribbean Sea, Alaskan waters, and the Western Pacific were recommended. In particular, the establishment of an air and submarine base at Guam, an island in the Pacific, was pressed. The provision of docking facilities for submarines at San Juan, Puerto Rico, and in the Panama Canal Zone, and of additional bases on the Atlantic coast of the United States and in Alaska, the enlargement of existing naval bases as well as other large-scale developments of port facilities for the fleet were included in the recommendations of the board.

In February, the House of Representatives rejected a proposal inserted in the Naval Air Base Bill, then before it, for the expenditure of £1,000,000 on harbour improvements on the island of Guam, but all the other provisions of the Bill, including those for eleven major bases, were authorised, the estimated expenditure on them being approximately £13,000,000.

The outcome of the decisions arrived at by Congress in the course of the year on the proposals of the naval board is a first instalment of contracts placed by the Navy Department, the particulars of which were announced towards the end of the year. They include a contract for making a naval air base at San Juan to cost £1,700,000 and others for similar bases in the Atlantic and Pacific to cost about £8,000,000. The last-named include Pearl Harbour, Midway Island, Johnston Island, Palmyra Island, and three bases in Alaskan waters.

The Panama Canal

The United States War Department also demanded, early in the year, that a third set of locks should be built in the Panama Canal. This demand is said to be justified on purely commercial grounds in view of the steady increase in the canal traffic since 1920. Nevertheless, the strategic aspect of the proposal has not been overlooked. It is intended that the third set of locks will be separated from the existing dual system by a distance of a mile or more, thus reducing the risk of simultaneous damage in an air-raid. The new locks will be considerably larger than the existing locks and, in fact, large enough to accommodate battleships of 45,000 tons. In August, the United States Secretary for War, Mr. Woodring, during a visit to the Panama Canal Zone, announced that work was to be started immediately on the building of the new locks, and, later in the month, the proposals were approved by Congress, the cost being estimated at 277 million dollars. The locks, it is said, will have internal dimensions of 1200ft. length, 135ft. width, and 45ft. depth. The minimum low-water depth in the approach channels will be 40ft.

It was on August 15th, 1914, more than 25 years ago, that the first ship passed from sea to sea through the Panama Canal. Since then well over 100,000 vessels exceeding 300 tons register have passed through the waterway, carrying over 500 million tons of cargo.

The Nicaraguan Canal Project

We recorded a year ago that the Federal Government had under consideration the construction of a second and independant isthmian canal in Nicaragua, as an alternative to the enlargement of the Panama Canal. In spite, however, of the decision to proceed with the latter scheme, it was announced in August that a board of American engineering and medical experts had been sent to Nicaragua to conduct a further preliminary survey for a canal across the isthmus. It was stated that this mission was the outcome of conversations betweeen President Roosevelt and President Somoza of Nicaragua during the latter's visit to Washington earlier in the year. Various estimates have been made of the probable cost of a Nicaraguan ship canal, the estimate based on a survey made by United States army engineers in 1929–31 amounting to £145,000,000. The estimate of the annual cost of maintenance of this canal was £2,000,000. The plan based on the 1929–31 survey provided for two flights of locks, one at each end of the canal, which was to have a total length, including the channel through Lake Nicaragua, of 173 miles. The locks were to be 1000ft. long and 120ft. wide internally, compared with the existing Panama locks which are 1000ft. long and 110ft. wide.

The Tennessee Valley Project

Work has begun on the largest dam included in the Tennessee Valley project, that to be made at Gilbertsville in Kentucky, about 23 miles above the junction of the Tennessee River with the Ohio River. The estimated cost of this dam, including the expenditure on power developments, is 112 million dollars. The primary objects of the dam are flood control and the provision of a navigable channel having a minimum depth of 9ft. The pool formed by the dam will extend 184 miles upstream, making a reservoir of over 6 million acre-feet, largely for controlled flood storage. In the dam there will be a navigation lock of similiar dimensions to those that have been provided in the other dams built in the Tennessee River, namely, 600ft. long and 110ft. wide internally. The lift of the lock will be about 55ft. The time allowed for the building of the Gilbertsville dam in the Authority's programme is six years.

United States Harbours and Waterways

Among the works of major importance in hand, or recently completed, on the waterways and in the sea ports of the United States may be mentioned the following:—The enlargement of the Cape Cod canal to provide a channel 32ft. deep and 500ft. wide was expected to be completed at the end of 1939. The principal approach channel to New York harbour—the Ambrose channel with its extension, the Anchorage channel—is being dredged to a depth of 45ft. at mean low-water: the intended minimum channel width of 2000ft. over the whole of the twelve miles of the channel has not yet been attained, but a depth of 45ft. is now available throughout its length. The channels of Boston harbour are being further extended and deepened and the improvement and enlargement of the New York State barge canal from the Hudson River to Oswego on Lake Ontario is still in progress.

A year ago we recorded the completion, excepting some part of the deepening of the approach channel, of the reconstruction and enlargement of the Chesapeake and Delaware ship canal, between the Delaware River and Chesapeake Bay. The works remaining to be done a year ago have now been completed. The reconstruction has been carried out by the Federal Government under the Emergency Relief Appropriation Act of 1935.

Projects for channel improvements in the St. John's River to Jacksonville, the Sabine–Neches waterway in Texas, and the Houston ship channel also in Texas, are in hand; the latter navigation is being deepened to 36ft.–37ft.

The new locks and dams on the Illinois waterway and the limited diversion of waters from Lake Michigan, by means of which a stabilised channel 9ft. deep has been secured, were brought into use during the year.

Many of the twenty-six locks and dams to be constructed on the upper Mississippi are completed, and a beginning has been made on all the remainder. This river canalisation will secure a channel of 9ft. minimum depth throughout the length of the navigation.

A report has been submitted to Congress recommending the construction of a canal connecting the Ohio River and Lake Erie at a cost of over 240 million dollars. The minimum navigable depth of the canal is proposed to be 12ft., the width being 250ft.

The Bonneville Dam

One of the largest individual works for the improvement of river navigation undertaken in recent years by the Federal Government of the United States is the Bonneville Dam. This project is now completed and affords the means of deep-water navigation on the Columbia River from the Pacific Ocean through the Coast Range of mountains to the Dalles. The cost has exceeded 40 million dollars. In addition to the improvement of navigation the dam stores water for the generation of electric power, the power-house being built in a branch of the river adjoining the navigation lock. The latter has internal dimensions of 500ft. by 76ft., and a lift of 66ft. above low-water level in the river. The Bonneville Dam, which has been built under the direction of the Corps of Engineers, U.S. Army, is situated some 42 miles east of Portland, Oregon. Deep-sea shipping can now go up the river to a point 95 miles above Portland.

Fort Peck Dam

The partial failure, towards the end of 1938, of the great hydraulic-fill dam at Fort Peck on the Missouri River, which we recorded in our review a year ago, has delayed the complete realisation of the improved navigation conditions on the river which will follow the release of the stored water to be retained above the dam. The pumping of the hydraulic-fill required to make good the damage done by the slide in 1938 was completed early in November, 1939. The total volume of fill pumped by the dredgers in making the dam has exceeded 122 million cubic yards. The dam was described in THE ENGINEER of April 16th and 23rd, 1937.

The St. Lawrence Waterway Project

A year ago we referred at some length to the progress of the negotiations between the Governments of the United States and of Canada regarding the projected deep-water navigation canal between the St. Lawrence River and the Great Lakes. Since October, 1938, when President Roosevelt made favourable reference to the proposed treaty during his visit to Canada, little seems to have been done to further the negotiations, at any rate so far as public knowledge goes. But in a recent issue of the *Canadian Engineer* there is a note which states that, according to reliable sources, negotiations are to be re-opened between the Dominion and United States Governments for the immediate undertaking of the development works. The aggregate of the estimates of the cost of the new navigation, the development of electric power, and the further deepening of the Welland Canal, all of which are associated in the project, is upwards of £82,000,000, about two-thirds of which would be borne by the United States, and one-third by Canada.

The St. Lawrence River Channel

It has been stated in the Dominion Parliament by the Minister of Transport that the completion of the 35ft. deep channel of the St. Lawrence River from Montreal to the Gulf was expected to be realised in 1943. The total cost of the work, it was said, would be about 80 million dollars.

Trinidad

The deep-water harbour works at Port of Spain recently completed by the contractors, Edmund Nuttall and Co., Ltd., were taken over by the Government in October. Work was begun on the harbour in 1935, Messrs. Coode, Wilson, Mitchell, and Vaughan-Lee being the engineers. The total cost of the harbour works will approach £1,000,000.

Hitherto, ocean-going vessels have been obliged to anchor two or three miles from the shore at Port of Spain. Now they can discharge and take in cargo at a deep-water wharf, 3170ft. long, upon which five transit sheds have been built. 160 acres of land have been reclaimed, and there is, at present, a depth of 30ft. at low-water alongside the wharf and in the approach channel. The works have been designed for an ultimate depth alongside the wharf of 32ft.

AUSTRALIA

Sydney

Following the decision of the Commonwealth Government, announced in December, 1938, to construct a large dry-dock at Sydney capable of accommodating the largest battleships afloat,

arrangements were made for Sir Leopold Savile to visit Sydney as well as several other Australian ports, and to advise the Government on the most suitable site for a dry-dock and repair yard. Sir Leopold has returned from his mission and, we understand, his report has been presented to the Commonwealth Government.

Melbourne

The Melbourne Harbour Trust have approved a scheme of harbour extensions estimated to cost £3,500,000. This work includes a considerable addition to the berthage for large ships in the Appleton Dock. Work on six new berths is now in hand, a contract for this first section of the scheme having been placed early in the year with the Netherlands Harbour Works Company of Amsterdam.

Port Kembla (N.S.W.)

The Department of Works and Local Government of New South Wales have virtually completed the first stage of the construction of a new harbour at Port Kembla, an open bay on the coast line about 45 nautical miles south of Sydney and midway between that port and Jervis Bay. Work on the new port, which serves the extensive Southern Coalfields situated in the hinterland, was begun in 1900, but proceeded slowly at first. The two rubble-mound breakwaters, one 3750ft. long and the other 3263ft., have now been completed. Within the shelter of these breakwaters jetties have been built at which coal is shipped. The depth of water at the entrance to the harbour between the breakwater heads varies from 48ft. to 54ft. at low-water. Depths of from 42ft. to 24ft. are provided alongside the jetties recently completed. The expenditure on the harbour work has been upwards of £1,200,000, of which over £800,000 has been spent on breakwater construction.

Mackay Harbour

The harbour extensions at Mackay (Queensland), mentioned in our review a year ago, are making good progress. The new southern breakwater of rubble-mound construction is now practically complete and good progress has been made with the northern breakwater, a structure of similar type. The two breakwaters aggregate a length of over 7700ft. The total cost of the extensions is estimated to be £1,000,000.

Oil-Engined Rail Traction in 1939

No. III

(*Continued from page 59, Jan. 19th*)

John Fowler and Co. (Leeds), Ltd.

DURING 1939 this firm concentrated mainly on the production of oil-engined shunting locomotives, principally for 4ft. 8½in. gauge, with Fowler-Sanders compression ignition engines. Repeat orders for 27 locomotives were obtained, and a record year is reported.

The Fowler standard range of oil-engined shunters incorporates a mechanical transmission through a multi-plate clutch and constant mesh gear-box—the type which has been in production for some years past. Two new locomotives, generally similar in construction, except for the power of the engine, are, however, being built with novel features. An accompanying drawing, Fig. 21, shows the general arrangement of the larger of the two, an order for the Air Ministry. It is rated at 200/220 B.H.P. and is of the 0–6–0 type, for standard gauge. The drive is taken through a Vulcan-Sinclair "Traction" fluid coupling, fitted with an idling drag eliminator, and a synchromesh gear-box made by Bostock and Bramley, Ltd., to the designs of the Hydraulic Coupling and Engineering Company, Ltd. The arrangement is similar to that described in the previous articles in this series. All gear changes—both up and down—are made by means of a small lever operating pneumatically-controlled valves in the gear-box. A provisional patent has been secured by Bostock and Bramley, Ltd., on the single lever control. The second locomotive is rated at 110 B.H.P., and is on order for an oil company for service in Palestine.

The leading particulars of the 200/220 B.H.P. locomotive are as follows :—

Engine : Fowler-Sanders four-stroke	Type 6 C
Number of cylinders	Six
Bore and stroke	7in. by 9in.
Continuous rating at 1000 r.p.m.	200 B.H.P.
One-hour rating at 1000 r.p.m.	220 B.H.P.
B.M.E.P. at continuous rating	76 lb. per sq. in.
Approximate weight of locomotive	34 tons.
Length over buffers	25ft. 7in.
Fuel tank capacity	80 gallons.

Three speeds, forward and reverse.
Tractive effort at 80 per cent. efficiency :—

	At 4 m.p.h.	At 7½ m.p.h.	At 12 m.p.h.
Continuous rating	15,000 lb.	8000 lb.	5000 lb.
One-hour rating	16,500 lb.	8800 lb.	5500 lb.

The wheels have a diameter of 39in., and the intermediate pair are flangeless. Compensated spring gear is adopted for the intermediate and trailing wheels and separate springing for the leading pair of wheels. In addition to a hand screw brake gear, Westinghouse air brakes, capable of independent or combined action acting on all six wheels are fitted. Compressed air is also used for operating the sanding gear and the warning horn. Starting is effected by means of a Fowler-Sanders twin-cylinder 18/20 H.P. auxiliary petrol engine. Dual controls are arranged for the fuel-injection system, gear changing and reversing, and the air brakes, so as to enable the driver to operate the locomotive from either side of the cab.

In Figs. 22 and 23 is shown the three-speed gear-box unit. The forward, reverse and change-speed gears on the locomotive are fitted with synchromesh rings so that engagement can only be made on synchronism. The unit is also provided with a synchronising clutch which is used during the operation of changing from a lower to a higher gear. The arrangement is such that forward or reverse gears can be engaged without shock, and

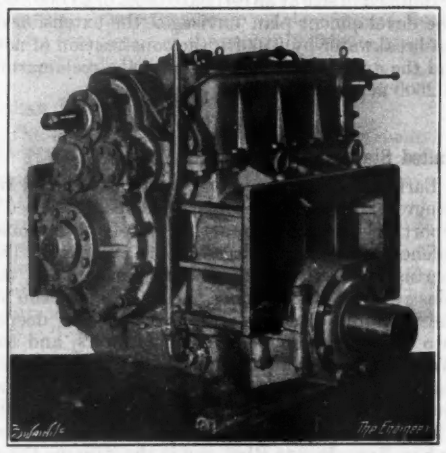


FIG. 22—SYNCHROMESH GEAR-BOX

so that the gears are freed from contact when it is desired to disengage any of them for changing speed. The gearing has been designed and manufactured by Bostock and Bramley, Ltd., and the firm's usual practice is followed in employing helical gears in constant mesh, the running members of which are carried on roller bearings. All shafts are mounted on ball or roller bearings in a cast-iron case, and are lubricated under pressure. Manipulation of the single lever control to the selected direction and speed ensures automatic operation of the synchronising clutch and gear change, effecting synchronous engagement without moving the fuel control. The air valves incorporated in the control can be seen at the top left-hand of Fig. 23, forming a compact assembly, and the rotary shaft for the reception of the control motion can also be seen. A graduated plate marked with the various control stations is fixed to this shaft. It is claimed that this arrangement not only ensures that the driver carries out the operations in their correct sequence, but also conduces to long gear life and produces a rapid

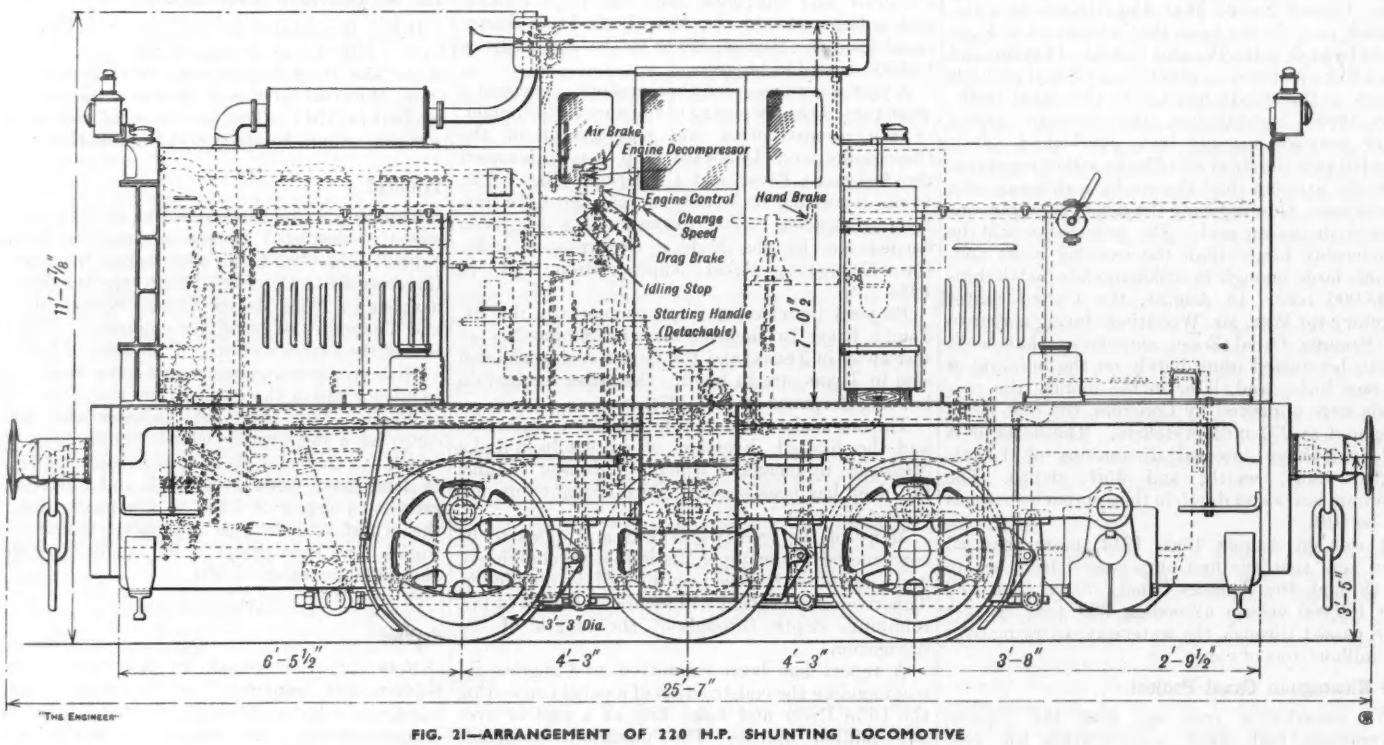


FIG. 21—ARRANGEMENT OF 220 H.P. SHUNTING LOCOMOTIVE

change in gear ratios without shock, tractive effort being meanwhile maintained.

Apart from these two large locomotives, John Fowler and Co. (Leeds), Ltd., received, as has already been noted, many orders for smaller shunters to the firm's standard designs. The mechanical transmission of these locomotives is

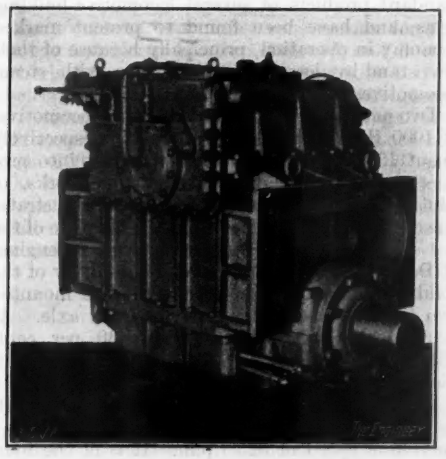


FIG. 23—SYNCHROMESH GEAR-BOX

of Fowler's own design, and a view of the standard gear-box is reproduced in Fig. 24. The engine torque is transmitted to the gearbox through a multi-plate clutch and a cardan shaft with flexible couplings. Constant-mesh gears are engaged by dog-clutches and are operated by a lever working in a gate. Bevel reverse gears are incorporated in

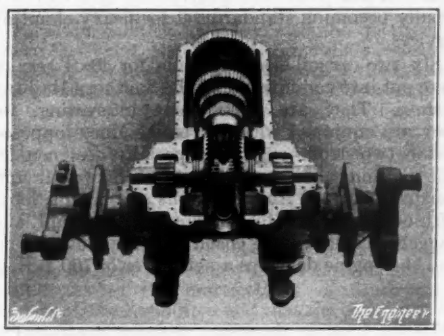


FIG. 24—GEAR-BOX AND FINAL DRIVE

the gear-box, and the final drive to the jackshaft is by means of large spur gears.

Leyland Motors, Ltd.

As far as railcars are concerned, the policy of this company is to manufacture only the principal units as applicable to light vehicles, the units being based on a ten-litre capacity petrol or oil engine, together with a Leyland torque converter embodying an over-run free wheel. The firm considers the free wheel to be particularly desirable for railcars with remote control, especially with multi-engine working, as it prevents damage being done in the event of the seizure of one of the units. In the engine and transmission units developed by the firm, the final drive is of Leyland design, embodying double-reduction gears with a reverse operated by means of a sliding pinion.

Recently Leyland Motors, Ltd., developed a new horizontal engine, designed for underfloor mounting in buses of the London Passenger Transport Board, and it was intended to have developed this engine for underfloor mounting in railcars, if the war had not intervened. Another development is in connection with supercharging. Recently the firm placed on test with the L.M.S. (N.C.C.) Railway Company, Northern Ireland, one of its ten-litre engines fitted with an exhaust-driven supercharger. The results of the trials are stated to be satisfactory, and further consideration is being given to supercharging, though not necessarily by means of the exhaust-driven type.

During the year 1939 several railcars with Leyland power and transmission units were put into service on the New Zealand Railways. Six double-bogie vehicles intended for main line service were constructed at the Hutt Valley workshops, Wellington. Views of one of the power bogies are reproduced in Figs. 25 and 26. A six-cylinder Leyland oil engine, with bore and stroke of $4\frac{5}{8}$in. and 6in. and a swept volume of 9·9 litres, is fitted to each bogie. At a speed of 1900 r.p.m., to which the engine is governed, the output is 120 B.H.P. The engine is flexibly mounted at the front and rear on rubber blocks carried on stout welded steel cross members attached to the engine. Transmission of power is through a Leyland (Lysholm-Smith) torque converter.

Radiators, with elements for cooling the engine water, engine oil, and torque converter fluid, are situated centrally, one on each side of the vehicle. The radiator elements contain only water, and heat exchangers, suitably placed on the torque converter and engine, are used to transfer the heat contained in the torque converter and engine oil to the cooling water. For operating the air brake and controls air is supplied by a Westinghouse compressor, driven by vee belts from the fan shaft, which, in turn, is driven by a quadruple belt from a pulley on the engine crankshaft and through a series of cardan shafts.

Each railcar can be operated singly from either end of the car or in multiple from any of the driving positions in the train, the cars being arranged for indiscriminate coupling. The drive from the torque converter is taken through a cardan shaft with two universal joints to a final drive and reverse gearbox (Fig. 27) mounted on the inner axle of each bogie. A short cylindrical member with spherical ends and rubber cushioning blocks is used to absorb the torque reaction. The engine, torque converter, and drive are set on the bogie at an inclination of 1 in 20.

All the controls are operated electro-pneumatically. The throttle control incorporates Westinghouse self-lapping valves, one in each driving cab, and the throttle responder is mounted on the engine, directly coupled to the fuel pump lever. For controlling the torque converter and reversal of the drive, electro-pneumatic valves are controlled by means of switches on the driving panels. A dust-proof sheet metal box houses the electro-pneumatic valves, relays, and other control units in an accessible position on one side of the bogie, and jumpers are used for the electrical connections between the bogie and the vehicle.

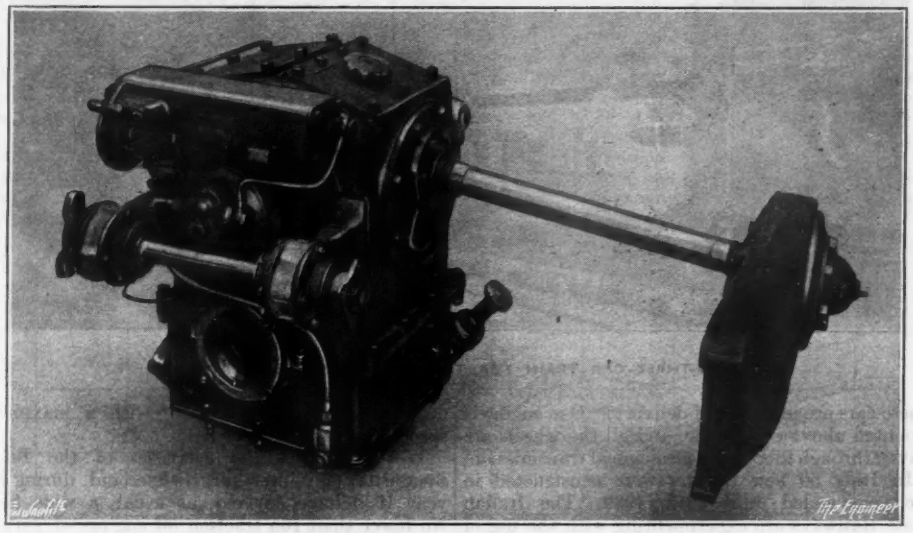
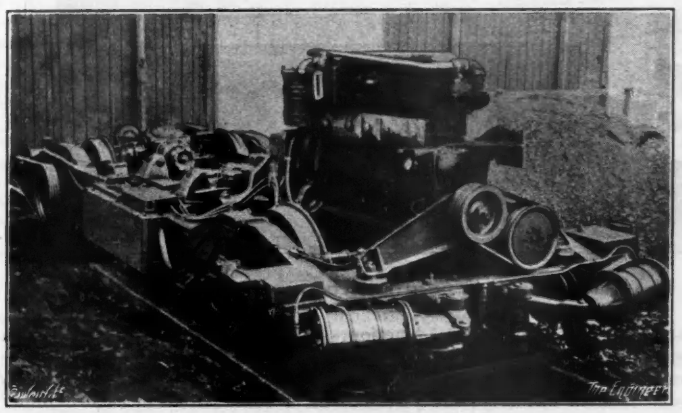


FIG. 27—FINAL DRIVE AND REVERSE GEAR-BOX

PRODUCTION ABROAD

By reason of delays in the postal systems and the dislocation of many firms' activities caused by the outbreak of war it has proved difficult to collate much information regarding the recent output of railcars and locomotives from manufacturers abroad. Oil-engined rail traction has, nevertheless, made good progress in the past year, particularly in France, the United States, the South American States, and other countries where its use has been successful for some years past.

In view of the need for conserving imported raw materials much attention had been paid in France to the use of producer gas for rail propulsion, using charcoal or wood fuel. Experimental railcars have been equipped with producers, and although they are not altogether satisfactory from the railway point of view, the present situation may force the S.N.C.F. to extend the experiment. A large railcar, built by De Dietrich, was operated on the Région de l'Ouest of the S.N.C.F. last year. The vehicle is fitted with a modified Panhard twelve-cylinder vee petrol engine, developing on producer



FIGS. 25 AND 26—POWER BOGIE OF RAILCARS FOR THE NEW ZEALAND RAILWAYS

gas 270 B.H.P. at 1750 r.p.m. as compared with 400 B.H.P. at 1650 r.p.m. on petrol. The fuel is burnt in a vertical producer mounted at one side near the centre of the car, the fuel being carried in sacks up a ladder and charged through a hole in the roof. Old railway sleepers are reported to be a favourite fuel. The gas cleaners and coolers are carried below floor level, and access to them is obtained through a side panel. A range of 300 miles is claimed.

An important series of railcars, of high power and designed for trailer haulage, consists of thirteen double-bogie Renault vehicles, each fitted with two Renault 300 B.H.P. twelve-cylinder engines. These cars are in course of delivery. One engine is mounted above each bogie, and all the wheels are driven through four-speed mechanical transmission.

In Italy 50 new railcars were constructed in the year ended June 30th, 1939. The Italian State Railways are experimenting with the use of methane gas in modified oil engines, and experimental Ansaldo cars with charcoal-burning producer gas plants are being run between Genoa and Milan. The Italian licensees of S.A. Adolphe Saurer, of Arbon, Switzerland, report that Saurer BXD oil engines have been ordered in large numbers for use on the Italian State Railways' railcars. A view of one of these engines is reproduced in Fig. 29.

In Hungary, Ganz and Co. reports the receipt of orders and the construction of many railcars during the past year. We have chosen for illustration in Fig. 28 a three-car set recently supplied to the Argentine State Railways. This railway system has had much experience of Ganz vehicles of all types, and as long ago as 1936 placed orders for three-car units for service on its broad gauge lines. Other types followed and last year an order was placed for ten new three-car trains, this time for operation on metre-gauge lines. These trains incorporate new developments as regards passenger comfort; for example, the cooling equipments have been increased in capacity, and attention has been paid to preventing the ingress of dust. The trains are provided with kitchens and dining facilities, and well equipped toilet and washing compartments. Each three-car unit comprises two power coaches and a trailer coach interposed. Each of the power coaches is fitted with one power bogie on which is mounted a Ganz-Jendrassik oil engine with an output of 320 B.H.P. Fully laden, the weight of the three-car unit is 140 to 150 tons, and the maximum speed is stated to be 110 kiloms. per hour. In general the design of the mechanical parts follows the firms standard practice, mechanical transmission being used. We are informed that this latest order brings the total number of vehicles ordered by the Argentine State Railways from Ganz and Co. to 143 vehicles.

Nine standard 550 B.H.P. "Mo" type oil-electric railcars were delivered to the Danish State Railways by A/S Frichs, of Aarhus, bringing the total number of vehicles of this type in service on that system to 57. Each weighs 56 tons, and is designed for express service, with a maximum speed of 120 kiloms. per hour.

We learn that the activities of the Büchi Syndicate, of Winterthur, Switzerland, during the year 1939 have covered, as usual, a wide field. No fewer than 165 traction oil engines of various types were fitted with the Büchi system of exhaust turbo charging, the sizes of the engines varying from 200 H.P. to 2000 H.P. Most of the engines were installed in railcars, and a large number were accounted for by an order for the Netherlands railways. This order consisted of sixty-three 700 B.H.P. Maybach engines. Many German railcars were equipped with the same type of engine, including the specially designed Kruckenberg railcar with which a maximum speed of 134·5 m.p.h. has been reached. Some railcars formerly equipped with ordinary oil engines were furnished with Büchi turbochargers. An interesting example of such a conversion are some oil-electric railcars of the Swiss Federal Railway. In one of these cars the output has been increased from 420 B.H.P. to 600 B.H.P. Superchargers were also fitted to a number of locomotives, notably two built by the S.L.M. Company at Winterthur. They are each equipped with a Sulzer 1200 B.H.P. oil engine, and the electrical equipment is of Brown, Boveri manufacture. Another notable example is the Hunslet 39-ton locomotive, referred to in an earlier article in this series, built for the Peruvian Corporation for service on the Guaqui—La Paz Railway.

In the United States there was much activity during the year, and a large number of new streamlined oil-electric trains and shunting locomotives were put into service. Large shunting locomotives, of about 2000 H.P. and downwards, are becoming standard products of several locomotive-building firms, and have been found to present marked economy in operation, principally because of their low stand-by losses, in comparison with steam locomotives.

Two new types of standard shunting locomotive, of 1000 H.P. and 660 H.P., weighing respectively about 120 tons and 100 tons, were put into production by the Baldwin Locomotive Works, of Philadelphia. Our engraving, Fig. 30, illustrates one of the 1000 H.P. locomotives. They are of the 0–4–4–0 type and are fitted with single oil engines of De La Vergne manufacture, a subsidiary of the Baldwin company. On each bogie are mounted two traction motors, one driving each axle. At starting the tractive effort with 30 per cent. adhesion is 72,000 lb. The main generator is directly coupled to the engine and is provided with a winding for starting purposes. The eight-cylinder engine is designed for operation at a maximum speed of 625 r.p.m. It is of the four-stroke type, and spherical water-cooled chambers cast integrally with the cylinder heads are provided.

It is interesting to note that the locomotives under construction to this specification represented an initial investment of more than 2,000,000 dollars by the Baldwin Locomotive Works for plant and stock to build a group of twenty-eight locomotives in line production, regardless of whether orders for them were received beforehand. This policy demonstrates that locomotives in America are rapidly becoming standardised for heavy shunting services.

Six two-car oil-electric trains for local service were put into commission by the Southern Railway system. They are particularly interesting, for they are equipped with Fairbanks-Morse opposed piston two-stroke engines, especially designed for rail traction. The power car of each two-car unit weighs about 114 American tons and is 80ft. long, with compartments for the power plant, mail, and baggage. The trailing coach weighs about 62 tons, and the engine develops a net power of 750 B.H.P.

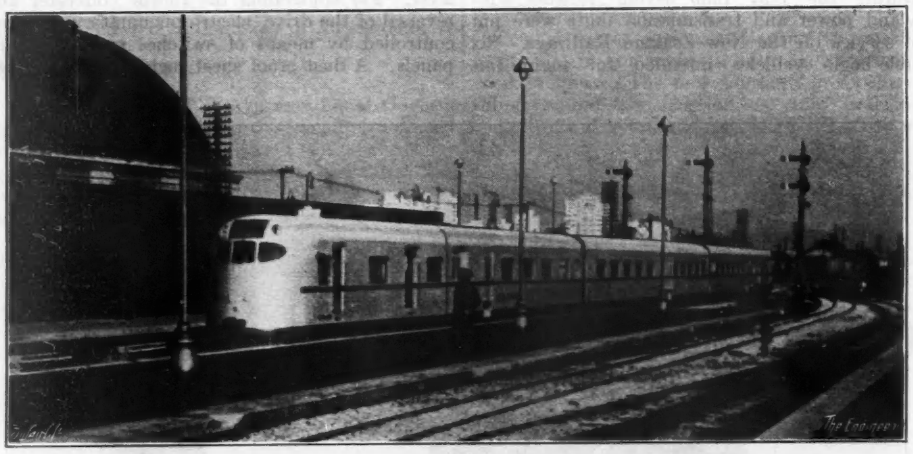


FIG. 28—THREE-CAR TRAIN FOR THE ARGENTINE STATE RAILWAYS

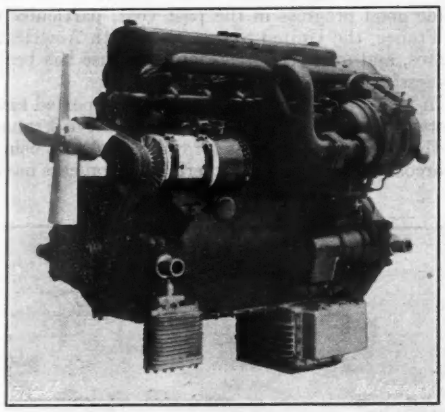


FIG. 29—ENGINE FOR ITALIAN RAILCARS

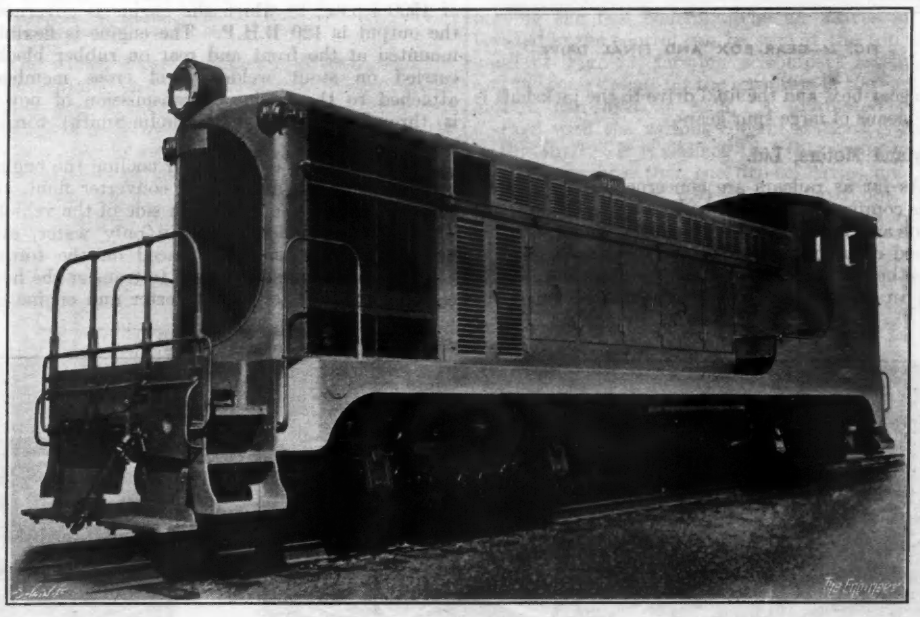


FIG. 30—AMERICAN 1000 H.P. SHUNTING LOCOMOTIVE

for traction. From one to three additional passenger cars can be hauled.

The engine has five cylinders and there are two 8in. pistons with a 10in. stroke in each cylinder. The continuous full-duty rating is 800 B.H.P. at 720 r.p.m., and the maximum rating 938 B.H.P. for one hour. Two pistons operate in opposite directions in each cylinder, with a common combustion space formed by the piston crowns, thus eliminating cylinder heads and valves. The upper pistons, controlling the scavenging air inlet ports, are connected to an upper crankshaft and the lower pistons, controlling the exhaust ports, are connected to a lower crankshaft. These crankshafts are mechanically connected by means

of a vertical shaft equipped with the necessary bevel gears and a flexible coupling. The engine is a complete self-contained unit with a rotary blower for supplying scavenging air. Supercharging is obtained by giving a small lead to the lower crankshaft, thus closing the exhaust ports slightly ahead of the inlet ports and allowing the manifold pressure to build up in the cylinders.

Many vehicles were under construction for the Chicago and North Western Railroad, and it was authorised to purchase two triple-unit 6000 B.H.P. oil-electric locomotives for hauling two fourteen-car streamlined trains between Chicago and California. The Illinois Central Railroad ordered seven 600 B.H.P., one 1000 B.H.P., and two 2000 B.H.P. Electro-Motive shunting and goods locomotives. Considerations of space forbid detailed descriptions of many other American locomotives and oil-electric trains.

Sixty Years Ago

THE FORTH BRIDGE

IT is still well known that at the time of the disaster to the Tay Bridge plans were well advanced for the construction of a double track railway bridge across the River Forth at Queensferry to the designs of the same engineer, Sir Thomas Bouch. Following the disaster, the Forth Bridge Railway Company—the promoters of the scheme—began to feel some doubt as to the sufficiency of the design. In 1873 it had appointed a committee of engineers consisting of G. P. Bidder, J. Hawkshaw, W. H. Barlow, and T. E. Harrison to report on Bouch's plans. That committee had returned approving, even enthusiastic, answers to the three main questions addressed to it, namely, the safety and suitability of the structure, the practicability of its construction, and the sufficiency of the sum estimated to be required to build it. Dealing with the question of safety it found that several important scientific considerations arose in connection with the design and it requested Mr. W. H. Barlow and Professor Pola to investigate them. Particular attention was paid to the wind load likely to be imposed on the bridge and to that end the Astronomer Royal furnished anemometer records taken at Greenwich. The committee came to the conclusion that the bridge completed to the design and dimensions and with the materials submitted to it would be "amply sufficient, not only for the safety of the ordinary traffic, but also to meet the strains due to extreme gales of wind." As to the practicability of constructing the bridge, the committee said that the chief point to be considered was the sufficiency of the foundation and accuracy. On the strength of the information supplied to it, it expressed "complete confidence" that the execution of the bridge, although of unusual magnitude, was quite practicable. Concerning the estimated cost, the committee had found that the quantities given by the designer were accurate and that, using its own experiences as to prices, the figure of £990,000 at which Mr. Bouch had estimated the cost was sufficient. It concluded its report with the words:—"It affords us great satisfaction to be able to give our sanction to a work of so imposing a character and to express our high approval of the skill, scientific research, and practical knowledge which have been brought to bear upon the elaboration of the details of this interesting work." Following the disaster to the Tay Bridge, the directors of the Forth Bridge Railway Company asked the committee to revise the statements made in its report of 1873, and the conclusions it had then reached, in view of any additional experience that might have been gained through the collapse of Bouch's bridge across the Tay. . . . A note to the above effect appeared in our issue of January 23rd, 1880. We have been unable to trace in subsequent issues any reference to the findings of the reconstituted committee. It is, however, a matter of history that Bouch's Forth Bridge was scrapped in favour of the existing design of cantilever bridge.

OIL WELL RECOVERY.—An article in the *Engineering Experiment Station News* of the Ohio State University describes some methods being adopted for the recovery of oil from wells which have been practically exhausted. By one of these methods holes are drilled round the well and water at a high pressure pumped into them. The pressure of the water has been found to concentrate the oil and increase the yield. By another method, developed by Mr. Leo Ranney, instead of drilling vertically through the overburden, with only a few feet of the well in the oil stratum, the hole is drilled down to the producing sand and then driven horizontally. It is stated that the first of these wells, a 2½in. bore some 900ft. from an outcrop, yielded oil by gravity and under suction although the area had been nearly exhausted by vertical wells. In a second application of the method, a shaft 30ft. in diameter and lined with concrete was sunk through the oil sand and holes at 15 deg. were drilled radially from its base. Alternate holes are being used for oil recovery and repressuring.

Mechanical Engineering for Power Stations*

By Sir LEONARD PEARCE, D.Sc., M.I. Mech. E.

No. I

[THE first part of the lecture reviewed the developments which have taken place at the Bloom Street, Stuart Street, and Barton Power Stations of the Manchester Corporation Electricity Department and at the Deptford West and Battersea "A" and "B" stations of the London Power Company with which the lecturer was associated as Engineer-in-Chief. The second part of the lecture dealt generally with some of the fundamental factors which have influenced the advancements made in the design and operation of power station plants, represented by the examples mentioned in the first part. From this second part we take the following extracts.]

STEAM CONDITIONS AND THERMAL EFFICIENCY

At the beginning of this century steam pressures were commonly about 150 lb. per square inch dry saturated, and this was soon increased to 190–200 lb. per square inch. Average pressures remained at this level for many years; but with a growing appreciation of the value of superheat, steam temperatures were gradually increased to 500, 600, and 650 deg. Fah., and during this period "bled" steam feed water heating was introduced, to yield feed temperatures of about 180 deg. Fah.

The next step was an increase in steam pressure to about 350 lb. per square inch and in temperature to about 700–750 deg. Fah, accompanied by an extension of bled steam feed heating to about 250 deg. Fah.

A further stage, which commenced about eight to ten years ago in this country, was the increase in pressure to 600–650 lb. per square inch, with a steam temperature of 800 deg. Fah. and feed heating to 300–350 deg. Fah. At the present time, many plants are in operation or under construction for these conditions with, in some cases, slightly higher steam temperatures of the order of 850 and 875 deg. Fah.

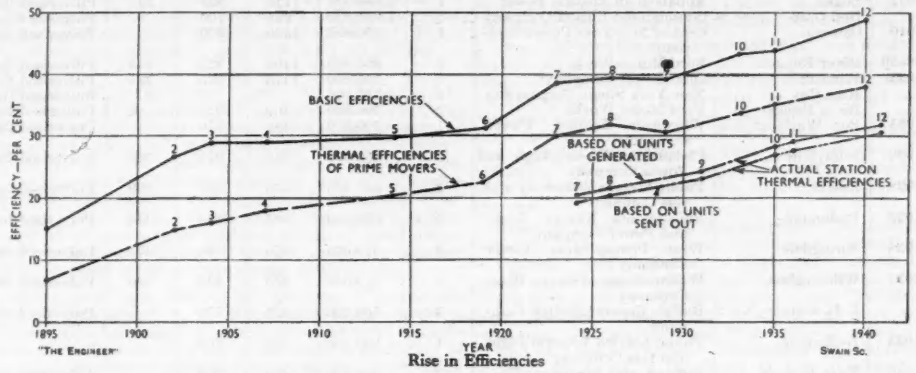
It is too early yet to mark any further very definite step, but plant is at present under construction for two stations at 1300–1400 lb. per square inch and 950 deg. Fah., with feed heating to 400 deg. Fah., and it seems probable that conditions of this order may become stabilised. These figures all relate to the straight regenerative cycle, for which the majority of plants in this country have been designed.

In the United States the steps taken to improve efficiency at a time when steam temperatures were limited by available materials to about 700–750 deg. Fah. were rather different, for pressures were increased to about 1200 lb. per square inch. To counteract the correspondingly high percentage of moisture which would be formed in the turbine exhaust with this high pressure and comparatively low temperature, the reheat cycle was adopted. Thus, whilst thought in this country was directed towards increasing temperatures, it was towards higher pressures that developments were taking place in the U.S.A.

One somewhat later plant in the States which has given outstanding performances in the last few years is the Port Washington Station of the Wisconsin Power Company, where a steam pressure of 1230–1320 lb. per square inch and temperature of 825 deg. Fah. were adopted, with the reheat cycle. A review of the latest practice in the States appears to indicate that since steam temperatures of 900–950 deg. Fah. have been shown to be practical, many plants are being designed for these temperatures with pressures of about 1200–1300 lb. per square inch, but without the complication of reheat.

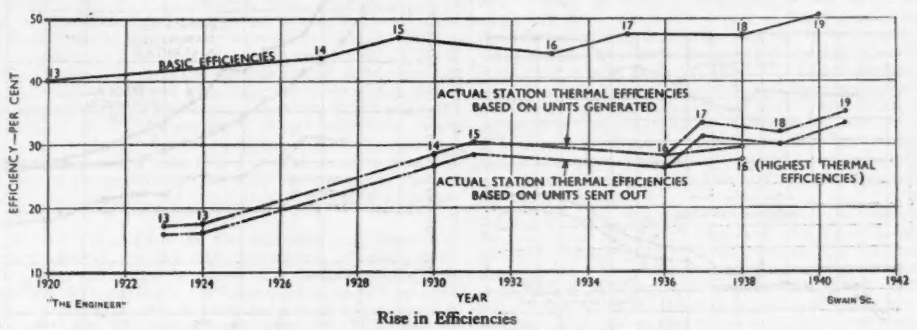
One of the latest and most interesting plants put into service in this country by the North Metropolitan Company at their Brimsdown "A" Station is operating at 1900 lb. per square inch and 930 deg. Fah. and uses the reheat cycle. The particular type of boiler selected for this installation made it essential to adopt a pressure of not less than about 1800 lb. per square inch; and with a limiting steam temperature of 930 deg. Fah, the reheat cycle had of necessity to be adopted to avoid excessive moisture. The terminal conditions were, therefore, to some extent determined by the type of boiler.

As to the highest pressure so far projected for steam power stations, this appears to be the 2400 lb. per square inch, 940 deg. Fah. plant for the Twin Branch Station of the American Gas and Light Company, operating on the reheat cycle to avoid excessive moisture with this very high initial steam pressure. It is anticipated that this plant will come into operation next year.



Rise in Efficiencies

FIG. 1—RISE IN STRAIGHT REGENERATIVE CYCLE EFFICIENCIES, 1895-1940



Rise in Efficiencies

FIG. 2—RISE IN REHEAT CYCLE EFFICIENCIES, 1920-1940

To demonstrate the effect on efficiency of increasing steam conditions, Figs. 1 and 2, have been prepared, the former referring to the straight regenerative cycle and the latter to the reheat cycle.

Records are not available for some of the earliest stations, but it is significant that since the beginning of this century the overall operating efficiency of power stations has risen from less than 10 per cent. to the present level of the order of 30 per cent., and the fact that the actual results are in line with the basic efficiency shows that these results have been attained largely by improving the steam conditions. I think we may look forward in the future to obtaining actual operating thermal efficiencies of the order of 35 per cent.

* From the Twenty-Sixth Thomas Hawksley Lecture, entitled "A Review of Forty Years' Development in Mechanical Engineering Plant for Power Stations," delivered before the Institution of Mechanical Engineers on January 19th, 1940.

Since 1923, annual returns of performance of power stations in this country have been published by the Electricity Commissioners. The figures for those steam stations which have achieved the highest thermal efficiency in each year are shown in Fig. 3, together with the corresponding basic efficiencies.

It is sometimes suggested that thermal efficiency is misleading and that there is a tendency to consider it as the only objective of operation at the expense of other sound engineering considerations.

Thermal efficiency is only important in so far as it is regarded in its appropriate perspective in the production of electricity at the lowest possible price. In considering any new project it is fundamentally necessary to deduce a figure for thermal efficiency which have been made on the supply industry as a whole.

In Fig. 4, therefore, the average fuel consumptions of all steam stations, both in this country and in the United States, during the last twenty years, have been plotted, and these curves afford ample evidence of the great strides which have been made in reducing the cost of generation of electricity. A third curve is shown giving the lowest fuel consumption of any station in this country, and it will be noticed that for some years now a figure of less than 1 lb. of fuel per kWh has been attained—an achievement which was probably considered to be beyond the bounds of possibility some twenty years ago.

It is of interest to note in passing that but for the

TABLE I—*List of Large Boilers Installed or on Order*

Date	Station	Operating company	No. of boilers	Capacity, lb. per hr.	Steam pressure, lb. per sq. in.	Steam temperature, deg. F.	Feed temperature, deg. F.	Method of firing
Great Britain								
1937	Battersea "B"	London Power Company	2	550,000	1420	965	400	Retort stoker
1935	Battersea "A"	London Power Company	3	375,000	625	875	355	Retort stoker
1937	Deptford West	London Power Company	1	350,000	375	780	240	Retort stoker
1938	Hams Hall "B"	Birmingham Corporation	4	350,000	670	845	340	Pulverised fuel
1928	Battersea "A"	London Power Company	6	312,000	600	830	355	Retort stoker
1938	Little Barford	Beds, Cambs, and Hants Public Supply Company	3	300,000	675	910		Pulverised fuel
1936	Deptford West	London Power Company	2	300,000	375	780	240	Retort stoker
1934–36	Hams Hall "A"	Birmingham Corporation	3	300,000	375	730	306	Pulverised fuel
1936–39	Hams Hall "A"	Birmingham Corporation	6	300,000	375	730	306	Chain grate
United States of America								
1929	East River	Consolidated Edison Company	3	1,250,000	400	725		Pulverised fuel
1937	Logan	Appalachian Electric Power	1	1,000,000	1425	925	383	Pulverised fuel
	Hell Gate	Consolidated Ediscn Company	2	1,000,000	265	700		Pulverised fuel
1940	Oswego	Central New York Power Company	1	900,000	1350	900		Pulverised fuel
1938–39	River Rouge	Ford Motor Works	2	900,000	1400	925	406	Pulverised fuel
1938	Windsor	Ohio Power Company	2	750,000	1475	925	395	Pulverised fuel
	Kips Bay	New York Steam Corporation	1	750,000				Pulverised fuel
	River Rouge	Ford Motor Works	2	700,000	1400	925		Pulverised fuel
1935	Port Washington	Wisconsin Electric Power Company	1	690,000	1390	750		Pulverised fuel
1938	Schuylkill	Philadelphia Electric Light and Power Company	2	660,000	1350	910	390	Pulverised fuel
1938	Essex	Public Service Electricity and Gas Company	2	605,000	1475	950	299	Pulverised fuel
1935	Richmond	Philadelphia Electric Light and Power Company	2	600,000	425	850	312	Pulverised fuel
1938	Springdale	West Pennsylvania Power Company	3	575,000	1450	935	425	Pulverised fuel
1937	Williamsburg	Williamsburg Power Plant Company	2	575,000	925	830	380	Pulverised fuel
	C. R. Huntley No. 2	Buffalo General Electric Company	4	560,000	425	750		Pulverised fuel
1935	Burlington	Public Service Electric Light and Gas Company	1	550,000	700	850		
1940	Twin Branch	Indiana and Michigan Electricity Company	1	550,000	2400	940		Pulverised fuel
1932	Hudson Avenue	Brooklyn Edison Company	8	500,000	440	750	270	Retort stoker
1938	Louisiana	Gulf States Utilities Company	2	500,000	650	750		Gas
	San Francisco	Pacific Gas and Electricity Company	3	500,000	1350	750		Oil and gas
	State Line	Chicago and District Gas and Electricity Company	4	500,000	1400	835		Pulverised fuel
1937	Waterside	Consolidated Edison Company	4	500,000	1400	900	386	Pulverised fuel

in order that an estimate can be made of fuel costs; and after making due allowances for reliability, continuity of supply, repairs, and maintenance costs, &c., the final test is the comparison of the savings in fuel cost to be obtained by the adoption of high-efficiency cycles, with the increased annual charges on the capital cost of such plant.

The choice of the heat cycle is peculiar to every station, and what may prove to be the best selection for a base load station will probably be quite unsuitable for a peak load station. As to the future, I think that it is not beyond the bounds of probability

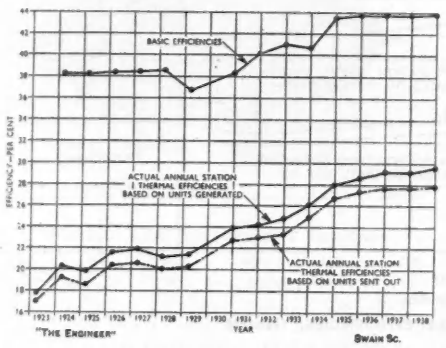

BASIC EFFICIENCIES
ACTUAL ANNUAL STATION THERMAL EFFICIENCIES BASED ON UNITS GENERATED
ACTUAL ANNUAL STATION THERMAL EFFICIENCIES BASED ON UNITS SENT OUT
EFFICIENCY—PER CENT
YEAR
"THE ENGINEER"
SWAIN SC.

FIG. 3—STEAM STATIONS HAVING HIGHEST THERMAL EFFICIENCIES IN YEARS 1923-38

that steam temperatures of the order of 1000 deg. Fah. will eventually be adopted, but I do not consider that very much is to be gained by exceeding operating pressures of 1500 lb. per square inch.

VARIATION IN FUEL CONSUMPTION OVER THE YEARS

In dealing with the general question of heat cycles I have attempted to illustrate the effect on efficiency of increasing steam pressure and temperatures, and I have shown the actual results which have been obtained in a large number of representative stations. It is, however, interesting to consider the general effect of the various improvements economies effected in coal consumption, an increase in production costs would have been inevitable as a result of the substantial advance in the price of coal during recent years.

[The lecturer then proceeded to describe and compare some typical early and present-day station layouts and followed with a discussion of developments in turbo-alternators and in boiler plants.

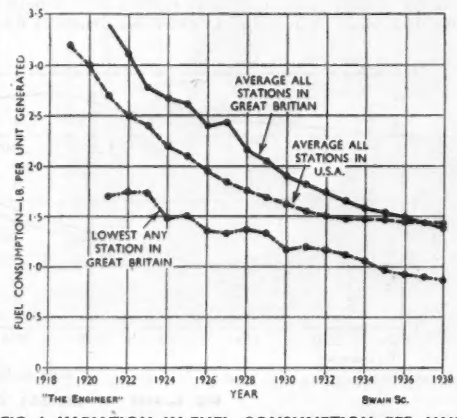


FIG. 4—VARIATION IN FUEL CONSUMPTION PER UNIT GENERATED IN STEAM STATIONS

In the section devoted to boiler plant developments he gave a table—reproduced above—of large boilers installed or on order. From the same section we intend to take in our next issue some remarks on forced circulation boilers.]

(To be continued)

CORRECTION.—In the article which appeared in our last issue on Herbert Akroyd Stuart and the Development of the Heavy Oil Engine, the name of the first author is given incorrectly. It should read T. Hornbuckle and not T. Horncastle.

Canadian Engineering News

Sinking Large Mine Shaft

A VERY interesting project was carried out recently on the property of the Asbestos Corporation of Canada, Limited, in the province of Quebec. This was the sinking of an unusually large mine shaft, known as No. 3, which replaces a temporary shaft sunk by the company following the adoption a few years ago of underground methods of mining asbestos. The temporary shaft and incline were within the ore body, whereas the new shaft is situated well outside the deposit. Designed to permit hoisting of 4000 tons of ore in 16 hours, with a generous allowance for delays, the shaft has five compartments, and has been sunk to an initial depth of 1150ft. It is steel timbered, chiefly to eliminate the possibility of bits of wood getting into the finished fibre. The company's engineering and operating staff designed and supervised the work. The skip-loading equipment consists of two measuring pockets, each with a capacity of seven tons of ore. The flow of ore into the pockets is controlled by two patented chain-gates, one gate being installed in each of the two upper chutes of the measuring pockets. The skips are of aluminium alloy and the weight of each is 7485 lb. The permanent headframe is an all-steel structure, 140ft. high, and is covered with asbestos-sheet siding. The hoists are completely equipped with safety devices. Large glass windows are provided in the control room so that the hoist operators may have a clear view of the control equipment from the hoist platforms.

Metallic Magnesium

During the last twelve months research has been initiated in the National Research Laboratories on the production of metallic magnesium. Canada possesses abundant supplies of magnesium-bearing minerals, and with cheap electric power the Dominion will be in a position to enter the field when the demand increases. Research has been undertaken to examine the Canadian raw materials, and to develop suitable methods for winning the metal therefrom. The production of the metal has been in very few hands, and the existing literature is confined almost exclusively to patents. An extensive search of the patent and general literature was the first step in this investigation. On the basis of the information obtained, the problem was resolved as follows :—

1.—Production of magnesium oxide from suitable Canadian minerals.

2.—Production of metal from the oxide by (*a*) electrolysis, (*b*) electro-thermic processes.

Experiments are under way on various methods for producing the oxide in reasonably pure form from magnesite, dolomitic magnesite, and serpentine, extensive deposits of all of which occur in Canada. The technical problem is readily soluble by use of chemical methods, but the economic aspects may not be so readily disposed of. Practical work on metal production has been confined to the electrolytic method. Special electrical equipment has been installed which is capable of delivering 600 amperes D.C. at a pressure of 30 volts. Experiments have covered production of the metal directly from the oxide in special electrolytes and also from the fused chloride.

New Refining Plant

A contract was recently awarded for the erection of a new plant for Consumers Co-operative Refineries, Ltd., in Regina, Saskatchewan, involving an expenditure of 250,000 dollars. Footings and concrete work will be started immediately and actual construction work will begin in March. The new plant will bring the daily capacity to 1500 barrels, compared with the present capacity of 500 barrels. The organisation will increase the storage capacity by 400,000 gallons, bringing the total storage capacity to nearly 2,000,000 gallons.

Shipbuilding Boom

A proposal to build patrol craft, submarine chasers, and possibly freighters in Canada will bring renewed activity to shipyards of the Dominion, where work has been slow for a number of years. It will also guarantee wider employment, depending, of course, on the size of the programme and the time period over which it will be planned. Canadian shipyards, though not laid out for the construction of very large vessels, are well suited for the type of craft under construction—that is, trawlers for coastal work, submarine chasers, and defensive craft to be used in guarding the Dominion's shores. Building of larger craft is also possible in a number of the yards. The eighty freighters of the former Canadian Government Merchant Marine—they ranged in sizes up to 7000 gross tons—were all constructed in Canadian yards. One of the main shipyards of Eastern Canada is at Montreal. During the last war, Canadian Vickers, Ltd., built a large number of vessels, including submarine chasers and submarines for the Royal Navy. Construction of underseas craft was then one of the biggest marine jobs handled in Canada. It appears likely that shipbuilding in Canada will again be an active industry.

Rail and Road

ROAD ACCIDENTS IN BRITAIN.—Official figures issued by the Ministry of Transport show that in December last more persons were killed on the roads of this country than in any previous month on record. Altogether 1155 people were killed and this number brought the year's total of fatalities up to 8270.

L.M.S. APPOINTMENTS.—The following appointment has been approved by the directors of the London, Midland and Scottish Railway Company. Mr. G. Thomson, Assistant (Electrical), Chief Mechanical Engineer's and Electrical Engineer's Department, Glasgow, to be Outdoor Machinery and Electrical Assistant, Chief Mechanical Engineer's and Electrical Engineer's Department, Glasgow.

GAS PROPELLED VEHICLES.—Further concessions to the gas propelled vehicle are indicated in draft regulations which the Minister of Transport has circulated to representative organisations. To remove the disadvantage which would otherwise result from the extra weight of the gas equipment, a weight allowance has already been given for taxation purposes. The draft regulations propose similar weight allowances, for purposes other than taxation, and will obviate difficulties as to lower speed limits, drawing of trailers, "vocational" licences, and attendants on trailers.

TRANSANDINE RAILWAY RECONSTRUCTION.—It is stated by a correspondent of the *Railway Gazette* that the Governments of Argentina and Chile are studying the possibility of expediting the reconstruction of the Transandine Railway, although, owing to the technical and topographical difficulties to be surmounted—necessitating the rebuilding of 43 km. of line, 10 tunnels, 7 large bridges, and a new station—it is estimated that the entire work will not be completed before the end of 1941 or early in 1942. The reconstructed railway will continue to follow the course of the Mendoza River, but with certain deviations and at a higher level than formerly.

A ROUMANIAN-BULGARIAN TRAIN FERRY.—Following the agreement in 1938 of the Roumanian and Bulgarian governments to establish a train ferry between Giurgiu and Rustschuk, work is now in progress and it is expected that the ferry will be completed during the present year. According to the correspondent of the *Railway Gazette*, there is a 656ft. jetty on each side of the river, and the end portions are made to raise or lower to meet the very great difference in the water level—some 24ft. 7in.—experienced during the year. The two countries are each to provide a ferry vessel, 213ft. 3in. long, with three lines of rails and accommodation for six bogie coaches and five goods wagons, driven by two 340 H.P. oil engines. The trip is to take about 70 minutes between the towns, with 38 minutes allowed for passing on and off the vessel. The importance of the new ferry is increased by the fact that very good long-distance roads converge on Giurgiu. The service will improve trade facilities over a considerable area in the Balkans.

POWERFUL NEW AUSTRALIAN LOCOMOTIVES.—The first of a new series of 4–8–4 passenger engines under construction at the Australian Government Railways shops at Newport is expected to be completed this year. With a tractive effort of 55,000 lb. they will be the most powerful engines in service in Australia. Their boilers have a working pressure of 220 lb. per square inch, a maximum outside diameter of 7ft. 3in. and, including the welded steel firebox, an overall length of nearly 45ft. They have three cylinders 21½in. diameter by 28in. stroke, the inside one of which drives the leading coupled axle and the outside ones the second pair of coupled wheels. Other leading particulars are as follows:—Coupled wheel diameter, 5ft. 7in., bogie wheel diameter, leading 2ft. 9in., trailing, 3ft. 1in. diameter; heating surface, tubes, and flues, 3613 square feet, firebox, 367 square feet, superheater, 800 square feet, grate area, 68 square feet, weight in working order 146 tons, and with tender 261 tons. The tenders have a capacity of 8 tons of coal and 14,000 gallons of water. The engines are to be partially streamlined.

FREIGHT TRAFFIC ON THE L.M.S.—Figures recently issued show that during the period September 1st to December 31st, 1939, London Midland and Scottish Railway Company operated the biggest number of loaded wagon miles (520,600,000) since the company came into existence. During the same period of 1938, the number of loaded wagon miles was 428 millions, so that the increase under war conditions amounts to no less than 92,600,000, or 21·65 per cent. The number of loaded wagon journeys represented is approximately 10½ millions. Mr. Ashton Davies, the Vice President of the company, says that on every day since the outbreak of war the company has run an average of 4000 freight trains for the conveyance of loaded traffic, without taking account of empty wagon trains. Since the war-time emergency timetable was introduced in September, progressive improvements have been effected until to-day the density of passenger services represents approximately 70 per cent. of the peace-time normal. Over and above this, however, the L.M.S. has already operated no fewer than 11,149 special passenger trains including military movement and leave trains, ambulance trains, &c.

PNEUMATIC TYRES FOR ELECTRIC TRAINS.—There has recently been completed by the Compagnie Electro-Mécanique the first electric train with pneumatic wheels of the Michelin type. It comprises three coach bodies on four bogies, each bogie having four axles. There are two driving axles per bogie, with four motors totalling 652 H.P. at the wheel tread, or 572 kW at the one-hour rating. The maximum speed is 120 km. per hour, and 256 passengers can be carried, of whom 180 are seated. It is claimed that the weight is about one-third of that of an ordinary train of the same capacity; that adhesion is greater, with less skidding, and that accelerating and braking efforts are larger. The tyres have an air pressure of about 9 kg. per square cm. and are mounted on wheel rims of the type common to heavy road trucks. The rail flange curves downward from the wheel on the inner side of the tyre, of which it is not a part. It is lined with rubber to suppress the transmission of noise. A cushion inside each tyre prevents the wheel sinking more than a limited amount if air escapes from the tyre, the loss of pressure being indicated by signal lamps inside the driver's cabin. Punctured wheels can be replaced by spares as with motor cars.

Miscellanea

DEATH OF MR. W. H. DICK.—It is with regret that we note the death, on January 9th, of Major W. H. Dick, managing director of Wailes Dove Bitumastic, Ltd. He joined the company in 1911 as a director, and eventually took over the entire management.

NEW BLAST FURNACES IN U.S.S.R.—The Commissariat of the Metallurgical Industry of the U.S.S.R. is building four new blast furnaces at the Magnitogorsk Combine, Azovstal, the Nizhny Tagil Works, at the Orjonikidze Metallurgical Works in Zaporozhe (Ukraine). The designed capacity of each of the furnaces is about 1400 tons of pig iron per day. The total estimated cost of each of them is 35 million roubles

EBONITE FROM SYNTHETIC RUBBER.—Experience in Germany is reported to have shown that synthetic rubbers may be vulcanised to the ebonite stage equally as well as natural rubbers, and that the properties of such products are only slightly different from those made from natural rubber. The application of the synthetic materials calls for greater care and in making moulded articles the shrinkage is greater and must be taken into account.

ROYAL GUNPOWDER FACTORY EXPLOSION.—As a result of an explosion at the Royal Gunpowder Factory at Waltham Abbey on Thursday, January 18th, five men were killed and about thirty persons injured. Although the sound of two violent explosions was heard a considerable distance away it is officially stated that the effects were localised as a result of the special lay-out of the factory. Normal working was resumed at the factory on Monday, January 22nd.

NEW COMPANY REGISTRATIONS.—According to the annual list of new company registrations, issued by Jordan and Sons, Ltd., there were 10,577 new companies with a total capital of £49,800,488 registered in this country during 1939. Of these 81 with a total capital of £240,825 were interested in aviation; 359 with £1,288,235 in electricity, water, or gas; 835 with £5,177,650 in engineering; 150 with £972,999 in metals; 97 with £2,210,066 in mines and quarries; and 518 with £1,269,300 in motors.

SMALL MANUFACTURERS AND WAR WORK.—The Federation of Manufacturers and Producers of Great Britain has interviewed representatives of the Ministry of Supply and the Air Ministry and discussed the problems of assisting small manufacturers in obtaining work. The Council of the Federation put the case of the smaller firms to the Ministry and after a full discussion of all aspects of the problem it was agreed that the Federation could be of assistance in enabling groups of small manufacturers to place information of their productive capacity at the disposal of the various supply departments.

ALUMINIUM FOR SHEATHING ELECTRIC CABLES.—An extract from the *A. E. G. Mitteilungen* in the *Electrical Review* gives particulars of some tests which have recently been carried out in Germany regarding the possibility of substituting aluminium for lead for the watertight sheathing of electric cables. The authors state that the tests have shown that 99·99 per cent. pure aluminium possesses mechanical properties equal to those of lead, and that the light metal can be compressed and handled at a temperature between 350 and 400 deg. Cent. in a press analogous to a lead press, producing aluminium sheaths which are not only watertight but show no breaks in the continuity of their structure.

A NEW FASTENING DEVICE.—A new fastening device for metal parts known as the "Speed Clip" is described in a recent issue of the *Iron Age*. It is designed to permit the fastening of parts together when it is not possible to gain access to the opposite side of the assembly. It consists of a tubular formation of spring steel which is packed into the hole. The forward end which enters the hole is curled inwards, whilst the outer end has a flange which seats on the outside of the hole. A plug or stud is pushed into the clip and as it is pushed home two tongues are sprung outwards to lock the clip firmly in the hole. When the stud is right home the curled end of the clip bites into it to lock it securely.

THE USE OF METHANE.—In a letter to the *Colliery Guardian*, Mr. H. T. F. Rhodes, joint honorary secretary of the Gas Traction Development Committee, says that, although the exact quantity of methane gas available in this country is not known, it amounts to many millions of cubic feet per day. A natural source in Scotland can supply between 10 and 12 million cubic feet a day and, if all sewage works in the country were producing and using methane, about five per cent. of the peacetime petrol requirements would become available. He points out that coke oven gas at present blown to waste is also a potential source of some 2800 million cubic feet of gas a year, or about one per cent. of the country's peacetime requirements.

FATIGUE STRENGTH OF CRANKSHAFTS.—A research is being carried out by the Institution of Automobile Engineers primarily to study the fatigue strength in bending of crankshafts for compression-ignition engines, since bending fatigue failures have been experienced in service. The information obtained is, however, proving of value in the design of all types of crankshaft. Three machines are in use. These machines apply reversed bending moments to the specimens, which are usually multi-throw crankshafts, one throw being broken at a time. The deflection is applied through a variable throw eccentric, and is calibrated in terms of bending moments. Failure occurs across the web, the crack starting from a fillet, and the nominal stress figure is calculated in the ordinary way from the modulus of the area of fracture. The fatigue limit is determined on a basis of ten million repetitions. A good deal of work has been carried out on these machines to study the fatigue strength of various designs of shaft in relation to the material employed. Recently, attention has been devoted more especially to various methods of surface hardening, including nitriding, chromium-plating, &c. In addition, owing to the importance under war-time conditions of salvaging worn parts for further use, a study is being made of the effect of certain processes, such as metal-spraying, for building up crankshafts.

Air and Water

SHIPPING LOSSES.—During the week ended January 13th British shipping losses due to enemy action totalled 12 vessels aggregating 34,077 tons and 4 neutral vessels of 7792 tons.

WELSH DRY DOCK REOPENED.—The increase in the number of ships using the South Wales ports in connection with the coal export trade has made possible the reopening of the Tredegar dry dock of Mountstuart Dry Docks, Ltd. This dock, which has been idle for the past eleven years has been reconditioned. It is capable of taking vessels of 14,000 to 15,000 tons and is 712ft. long by 65ft. wide.

NORWEGIAN PURCHASE OF AMERICAN SHIPS.—It is reported that a Norwegian company has purchased eight ships from the United States Lines, and that they have been transferred to Norwegian registry. It is understood that the vessels concerned are the "President Harding" and seven of the "American" class; and that they will be operated between New York and London, and New York and Liverpool.

THE ARMING OF THE MERCHANT FLEET.—According to *The Times*, more than half of this country's merchant fleet is now equipped with guns for the purpose of repelling attacks by submarines or aircraft. It is stated that a ship is fitted with one or two guns, according to her size, within eighteen days of reaching a port and asking for them. A trained gun crew is supplied with each one installed and a large number of seamen are now undergoing training in this class of work.

PROPOSED AMERICAN CRUISERS.—According to a statement by the chairman of the United States Naval Affairs Committee, legislation is to be redrafted to permit the construction of cruisers exceeding the 10,000 ton limit laid down in the London Naval Treaty. It was recently stated in the House of Representatives that 145 new warships will be required by 1945 to complete the building programme of the United States Navy. The estimated cost of these ships is 2276 million dollars.

SCHOLARSHIPS FOR THE MERCHANT NAVY.—A scholarship having an annual value of £50 has been placed at the disposal of the Merchant Navy by the Worshipful Company of Ironmongers. It is intended for those boys whose declared intention is to enter the Merchant Navy with a view to taking up careers as officers, and it will be tenable for a period not exceeding three years at one of the following officer training schools: H.M.S. "Conway," H.M.S. "Worcester"; or the Nautical College, Pangbourne.

LOSS OF THREE BRITISH SUBMARINES.—The Admiralty announces that as the three submarines "Sea Horse," "Undine," and "Starfish" which were engaged on particularly hazardous work have failed to return to their bases they must be regarded as lost. The "Sea Horse" and "Starfish" were similar vessels of 640 tons, armed with one 3in. gun and six 21in. torpedo tubes. The "Undine" was of 540 tons. It is reported by the German wireless that part of the crews of the "Undine" and "Starfish" have been rescued.

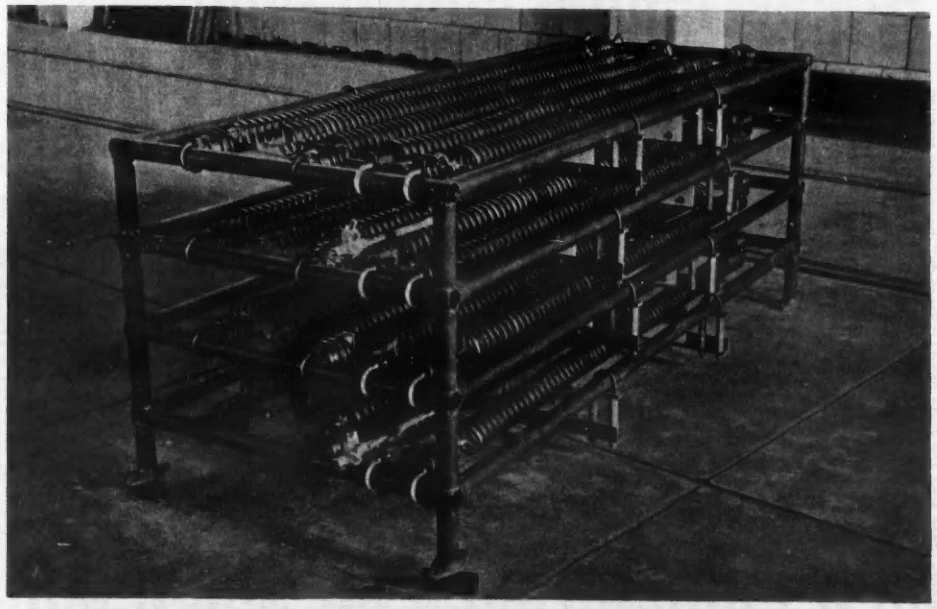
SUEZ CANAL SHIPPING.—As a result of the war, Suez canal shipping during the month of October was reduced to one third of its peacetime traffic. Southward bound traffic during October totalled 155 vessels carrying 376,954 tons of cargo and 9907 passengers. This compares with 256 vessels, 657,362 tons of cargo, and 23,302 passengers for the corresponding period of 1938. During the same month northward bound traffic totalled 150 ships carrying 1,001,707 tons of cargo and 5316 passengers, as against 264 vessels, 1,854,507 tons of cargo and 10,107 passengers for October, 1938.

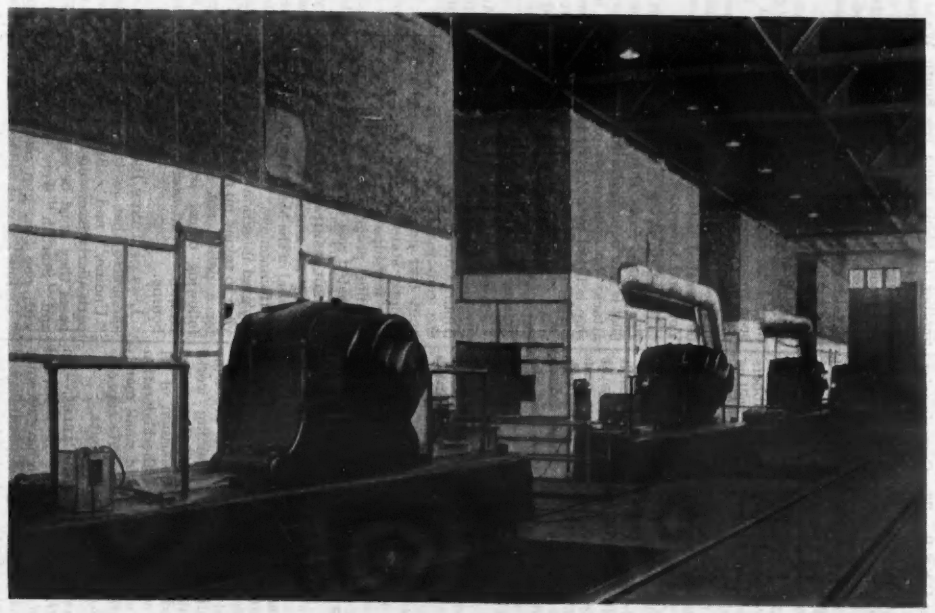
GERMAN INLAND WATERWAYS.—When the 25 miles long Adolf Hitler canal, between Gleiwitz and the Oder, was opened last month, work was officially started on the construction of the Oder-Danube canal which will join the Adolf Hitler canal at Blechhammer. The proposed canal will be nearly 200 miles long, and its object is to connect the Rhine, the Oder, and the Danube to complete a ring of waterways connecting in the north the Rhine, Weser, Elbe, and Oder with each other, the North Sea and the Baltic, and extending in the south to the Black Sea. Also, an easterly extension of the Adolf Hitler canal will bring the whole course of the Weichsel under German influence and open the way to a second connection with the Black Sea via the Dniester. According to an official statement storage basins completed or under construction at Ottmachau, Turawa, Klodnitz, and Berghof (Weisstritz) will increase the traffic capacity of the Oder, and others are expected to be built at Mora-Kreuzberg and Sponau. It is intended ultimately to build an Elbe-Danube canal, and in the meantime a connection will be established by a branch from Prerau on the Oder-Danube canal as soon as the latter is available.

MR. ROBERT STRACHAN'S JUBILEE.—On Saturday, January 13th, Mr. Robert Strachan, who holds the offices of joint managing director and engineering director of the Fairfield Shipbuilding and Engineering Company, Ltd., of Govan, Glasgow, completed exactly fifty years of service with his firm. He was apprenticed under the late Andrew Laing, and at that time the Atlantic mail steamers being built were fitted with triple-expansion steam engines, notable ships being the "Campania" and "Lucania" built for Cunard service. At that time the company was also building the "Normannia" for Hamburg-Amerika Line service, and other ships were constructed for the North German Lloyd Company. Mr. Strachan has had a wide experience in the construction of machinery for naval and mercantile vessels and he was intimately connected with the introduction of the Fairfield-Sulzer oil engine and its installation in the quadruple-screw liner "Aorangi." He comes of an engineering family, and his brother, the late Mr. George Strachan, was with the Fairfield Company for over fifty years, while another brother, Mr. William Strachan, was the chairman and managing director of Workman Clark of Belfast. At no time in the history of the Fairfield undertaking have the yard and machine ships been busier than to-day. We wish to Mr. Strachan many more useful and happy years with the firm he has served with such distinction.

DRYING OUT ELECTRICAL MACHINERY AT ONTARIO POWER STATION, CANADA

(*For description see page 78*)





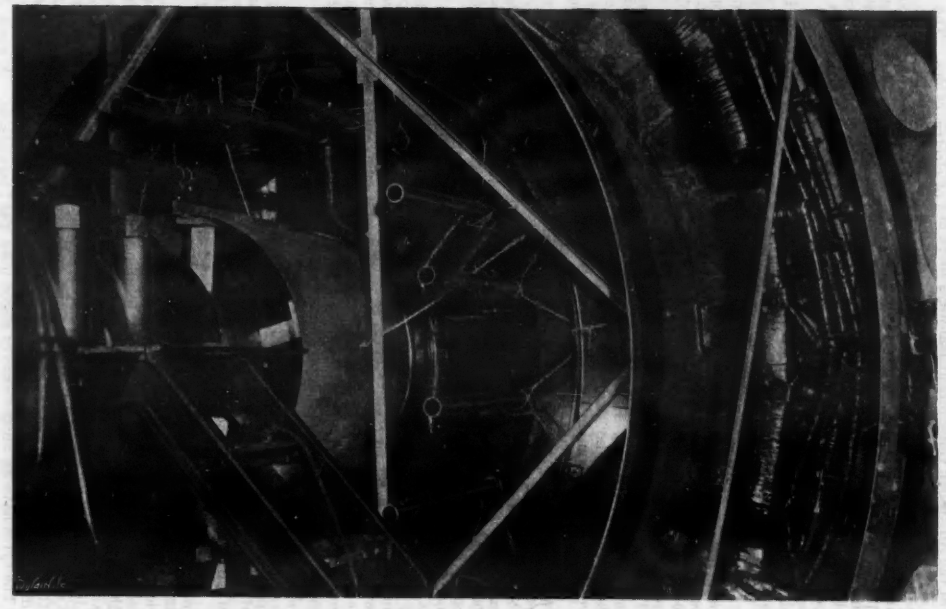


FIG. 5—150 kW ELECTRIC HEATER
FIG. 7—INTERNAL BRACING OF VACUUM TANK

FIG. 6—DRYING ENCLOSURE FOR 9000 kW GENERATOR
FIG. 8—LARGE VACUUM TANK

The Engineer

JANUARY 26, 1940

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THE DEVELOPMENT OF POWER STATION MACHINERY

THE wide experience of Sir Leonard Pearce in the design and management of large power stations made it particularly fitting that he should have chosen the development of power station machinery as the subject of the Hawksley Lecture which he delivered before the Institution of Mechanical Engineers last Friday afternoon. He has to his credit the Barton Station at Manchester, which held the British record for thermal efficiency for five years in succession; Deptford West, which achieved the record once; and Battersea, which retained it for three years and is likely to recapture it when the new plant is in operation. From one with such experience to draw upon, his audience had the right to expect a lecture of exceptional interest, and the event justified their anticipations. His review nominally covered the advances made during the last forty years, but the really historical part was very brief, and the developments during the period considered were illustrated almost entirely by the progressive improvements in practice exemplified in the particular stations with which the lecturer had himself been connected. This limitation unfortunately prevents the picture being broad enough to be fairly representative of the progress of the industry as a whole, for Manchester was still installing slow-speed reciprocating units in 1904, and by the time that City ventured upon its first turbo-generator in 1907 there were at least seven stations in the country, including such important plants as Carville and Lots Road, employing nothing but turbine machinery. The same reservation has to be borne in mind with regard to the tables showing the sizes of prime movers installed in steam power stations between 1895 and 1940. From these tables, in which certain American stations are included, one would gather that no turbo-generator larger than 20,000 kW had ever been built before 1920, whereas eight years before that time Messrs. Parsons had built a 25,000 kW unit for Chicago which is still in operation, and as long ago as 1922 the same firm undertook the construction of a 50,000 kW set for the same city. Were it not that the lecture will be read by engineers abroad, whose opinions of the enterprise and ability of British manufacturers might be adversely affected by the summary of facts presented, the matter would not have been worth mentioning, because, in spite of the title of the Lecture, its main interest lies much more in the account of the attainments that have recently been achieved than in any precise statement of the steps by which they have been preceded.

Some idea of the progress made during the last forty years will be gained by comparing the steam conditions and the size of generating units in use at the beginning and end of the period. In 1900 the largest turbo-generators in the world were the two 1000 kW single-phase Parsons units at Elberfeld, designed to work with steam at 150 lb. pressure with 90 deg. of superheat, and a vacuum of about 27in. To-day Sir Leonard Pearce can point to twenty-two machines of 100,000 kW and over, the largest being the 208,000 kW unit in the State Line Station at Chicago. Steam pressures from 1200 to 1500 lb. per square inch are now too common in large modern stations to be looked upon as anything very remarkable, and higher pressures still are in commercial use. Temperatures, too, have gone up from the 400 deg. Fah. or so at the beginning of the century to 800 deg. Fah. as common practice, and to 950 deg. Fah. in exceptional cases. We are, indeed, getting now very close to the limitations imposed by the strength of the materials at our disposal, and little further advance seems likely in the near future. As regards speeds, we have imposed our own maximum limit of 3000 r.p.m. on alternators by adopting 50 cycles as the standard frequency of alternating current, and units up to 60,000 kW are now operating at this speed. If we turn to the boiler-house, we find similar advances in design. A boiler capable of evaporating 12,000 lb. of water per hour was considered a very respectable unit forty years ago, yet to-day those evaporating 500,000 lb. and over can be reckoned by scores, while there are in the United States at least six boilers in existence with a rating of a million pounds or more. Such enormous developments in boilers and machinery have naturally been reflected in the performances of central stations. At the beginning of the century a station that could operate with an average consumption of five pounds of coal per kWh thought it had reason to be proud of itself. To-day the average consumption of all the power stations in Great Britain works out at less than 1·5 lb. of coal per kWh, a lower figure than is attained by a corresponding calculation for the United States, in spite of the immense and highly efficient plants of which that country can boast. The best British stations have been able, for some years past, to generate current for less than 1 lb. of coal per kWh. More significant, however, than coal consumption is the thermal efficiency obtained, for this eliminates the effect of differences in the quality of the coal burnt. The most highly efficient station in Great Britain at the present time is the Dunston Station of the North Eastern Electric Supply Company which, though outclassed both as regards size of units and magnitude of output by some of the other large plants, is turning nearly 30 per cent. of the heat of the coal burnt into saleable electrical energy.

Curves showing the rapid increase in the annual output of electricity in this country afford no indication that we are reaching the saturation point. Whether the greater demand in the future should be met by larger and larger stations equipped with bigger and bigger units, or whether the better course would be to limit the size of stations and increase their number is an interesting question. Sir Leonard Pearce makes no secret of his disapproval, on technical grounds, of the present tendency to favour the limitation of individual stations to a capacity of about 250,000 kW, which is less than half the capacity of the plant concentrated in one spot by one of the London companies—mainly in order to minimise possible damage in the event of war or accident. This policy, he considers, is certain to prevent the steady decrease in the cost of generation which would be attainable were there no restriction on size, and he hints that such restriction should be unnecessary as the Grid is there to ensure continuity of supply. Although, as he reminded us, the Grid has been of very great benefit by reducing the amount of spare plant that otherwise would have to be carried by individual undertakings, it is very questionable whether its existence has not been directly or indirectly responsible for more and wider interruptions of supply than would have occurred without it. If this had to be said in time of peace, can it ensure continuity of supply when subject to aerial attack and all the risks of enemy action? No sensible man would advocate the unnecessary multiplication of power stations, but there is an old proverb about carrying too many eggs in one basket, and so long as power stations of considerably less than the proposed limit of capacity can hold the record for efficiency, the ordinary consumer can hardly be blamed if he prefers a few more of them and a few less miles of high tension mains, to the theoretical advantages of huge concentrations of generating plant. Sir Leonard referred in his address to the importance of taking broad views, and it must always be remembered that the best engineer is not the one who can extract the very last scrap of energy out of a pound of coal, but he who can secure to the public the best possible service of electricity at a price that will encourage a further demand.

An Oil Engine Jubilee

THE Akroyd Stuart luncheon arranged by the Diesel Engine Users Association, which was held on Thursday, January 11th, and was referred to in last week's issue, was an event of historic importance, for it brought together not only the leading engineers of the British oil engine industry, but many pioneer workers who had taken part in Akroyd Stuart's development work. We find ourselves entirely in accord with the desire of the authors of the paper read after the luncheon to pay a tribute to the work done by a British inventor who, scarcely out of his 'teens, formulated the

general ideas which have since led to the successful development of the compression-ignition engine, and introduced pilot ignition and the cooling of the injection nozzle. The discussion of the paper brought to light several new facts concerning the early development of the Hornsby-Akroyd engine, and Major-General A. E. Davidson was able to bear witness from Army archives to the excellent performance of these engines, some of which were giving reliable service in the army up to a few years ago. The paper will fulfil a useful purpose, if, in looking back, we are enabled by it to see more clearly the steps by which success was achieved, and are encouraged to apply these lessons to the problems which now face us.

There is no doubt that 1890 was an epoch making year in the history of the British gas and oil engine, for at that time Crossley Brothers had just taken over the Otto patents, Akroyd Stuart had patented the forerunner of the compression-ignition engine, and, on the gas engine side, John Henry Hamilton had just patented his fourth supercharger. These were all matters of the first importance which together with the Diesel engine constructed by the Mirrlees Watson Company in 1897–98, and tested by Professor Watkinson, laid the foundations of later successes. In the development of the gas engine the work of Joseph Emerson Dowson, who died recently, should not be overlooked, or for that matter that done by Herbert Akroyd Stuart on the production of gas from Australian wood. Reviewing the early development of the Diesel engine, Mr. Charles Day pointed to the difference in the beginnings of the compression-ignition engine and of the high-pressure oil engine. Akroyd Stuart's work, he said, was based on experiment, whereas that of Rudolf Diesel had its roots in the thermodynamics and the theoretical cycle of Sadi Carnot, which was subsequently modified by practical engineers to meet the requirements of industrial and marine work. The progress of the real compression-ignition engine was retarded for many years by the successful low-compression engine with injection into an auxiliary chamber during the induction stroke, and it now seems as if Lord Kelvin, who advised Mirrlees concerning the Diesel engine, was alone certain of the possibility of igniting the fuel by the heat of compression. Akroyd Stuart's advisers, Professor Robinson and Lord Moulton, it would seem, were not sure of that fact, although self-ignition under constant load conditions was a well known phenomenon with the early Priestman oil engine. But whilst the two main streams of internal combustion design and development have proceeded from two different sources, one theoretical and one practical, both have contributed to sound progress. On the theoretical side we would recall the work of Nägel, Eichelberg, and Büchi on the Continent, which has done so much to throw light on temperatures of cylinder walls, pistons, and valves, and the flow of gases. In this country research has been as keen and as profitable as that of any other country and the list of names of men who have contributed to the progress of the internal combustion engine is formidable. On the practical side, the remarkable accuracy of the injection and combustion process revealed by the cathode ray oscillograph, the improvement of cast irons and valve steels, and the introduction of the rotary blower, either engine driven, or worked by an exhaust turbine, have all contributed to a better engine and a more economical performance. It is difficult to see what the immediate future of the oil engine will be, and the availability of fuel is a factor which cannot be overlooked. In a recent paper on the development of the high-speed oil engine in America, C. R. Maxwell and C. G. A. Rosen, engineers of the Caterpillar Company of Peoria, Ill., remark on the predominance of the auxiliary-chamber type of engine in the United States. They predict that, if the future demand grows and a supply of the lighter kerosine distillates is available, the tendency of design will be towards open-chamber engines, but if, on economic grounds, it becomes desirable to produce heavier fuel oils, the auxiliary-chamber engine, of which Akroyd Stuart was the undoubted inventor, will predominate. The engine designer must co-operate closely with the oil refiner. Recent events may indicate that the producer gas engine may be revived not only as a war-measure to conserve fuels, but as a permanent alternative to the oil engine. The coal-dust engine, always nearing perfection but never quite attaining it, must also be expected to play an important part in the future.

In the developments to which we have referred, much help was derived from the admirable papers, often written from the point of view of the user, which are to be found in the proceedings of the D.E.U.A. or Diesel Engine Users Association There has long been a feeling that "Diesel" is a misnomer, and everyone would welcome a change of name which would indicate the all embracing scope of the work of the association. Whether we shall in future hear of the O.E.U.A., Oil Engine Users Association, or the O. & G.E.U.A., Oil and Gas Engine Users Association remains to be seen. The Association is fortunate in having as its President Mr. George E. Windeler, who is himself an outstanding worker in oil engine design and can be trusted to direct it along the right lines for its future useful development.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

OVERSEAS ENGINEERS AND NATIONAL SERVICE WORK

SIR,—The letter from "Consultant" on "Consulting Engineers and Government Work" in THE ENGINEER of November 24th, 1939, raises a number of very pertinent points which are also germane in respect of the advantage taken —or rather, not taken —of the services available amongst senior British engineers abroad.

That full advantage is *not* taken is evident, at any rate to a good many engineers with overseas experience, by various lists of appointees which have been announced within the last month or two; indeed, without wishing to be invidious, it nevertheless needs to be said that such lists would appear to demonstrate a paucity of talent and experience in the engineering world not substantiated by facts.

A factor, possibly a considerable one, affecting this may have been—and so far still is—the "freezing out" of overseas engineers by a series of mutually-excluding conditions governing the selection of personnel; and as such, apparently paradoxical, conditions may not be known generally, the bringing to light of same may serve a useful public service.

These mutually-excluding Governmental conditions in regard to overseas engineers are as follows:—

(1) It is a condition of appointment to any National Service position in England that the individual concerned must be duly registered (and with completed Form) with the Ministry of Labour; whilst at the same time such Forms are not supposed to be sent out of the country.

(2) It is an instruction that aspirants for National Service—which of course includes engineers—in foreign countries must make their desires known, and have their qualifications recorded with the "nearest British authority"; at the same time Legations and Consulates in foreign countries, at any rate those within the knowledge of the writer, have so far been instructed not to forward such particulars to England.

As you will see there is a completely watertight blocking of the channels for making known from abroad the availability of an individual either by such person overseas himself or by proxy in Great Britain. The writer is aware of engineers abroad whose employers have arranged for their release under adequate conditions, yet owing to the foregoing "blocking" the results have so far been negative. In the opinion of the writer the situation mentioned in the second paragraph is to an appreciable extent due to the restrictions just referred to and it is suggested that the time has more than arrived when a change should be made in such an illogical proceedure, as being against the National interests.

MIDLOCO.

December, 1939.

ORGANISATION FOR SMALLER MANUFACTURERS

SIR,—As Chairman of the Federation formed to look after the interests of the smaller manufacturers in connection with war work and export trade, I desire to thank you on their behalf for the interest which you have shown in our movement.

I wish to inform you that we have made steady progress since the formation of the Federation on the 4th inst. Our membership is increasing daily, and we have been recognised by the Board of Trade, and also by the Ministry of Supply. I am meeting the Secretary of the Board of Trade to-day, to discuss the possibility of a number of the members of the Federation being able to undertake the manufacture of goods for export, such as were being manufactured by Germany for export, to foreign neutral countries.

The Federation sent a letter to the Minister of Supply last week requesting an early interview to be given to the Temporary Council appointed at our meeting at Holborn Restaurant, but the Minister is very busy this week, and has asked us to see the Director of Area Organisation to-morrow afternoon. We are keeping this appointment, but still desire to see the Minister, as the matter is of vital importance and requires the Minister's personal attention. We therefore look forward to an early appointment with Mr. E. Leslie Burgin.

The Federation is to be the small manufacturers' "Advocate" and through your paper we would ask all the small manufacturers, irrespective of what materials they make, to send us full details as requested by the questionnaire, specimen of which we enclose. I would stress the importance of this return being made at once, so that it may be analysed and the strength of this further information be added to that which we have, so that it may also be placed before the Minister.

Unity is strength, and this is the only way the small manufacturers will be able to receive their share of work, which is being given out.

Yours faithfully,

JOHN A. R. MCDONALD.

Temporary Offices:
30/40, Dalling Road,
Hammersmith, W.6.
January 16th, 1940

[The questionnaire referred to in the letter above is reproduced herewith for the information of those interested.

1. Name of Person, Firm, or Company. If the latter, whether public or private.

2. Address—
(*a*) Head Office.
(*b*) Works.
(*c*) Subsidiaries or Branches.

3. Products produced in Peace time.

4. Percentage of Export Trade with Countries to which Exported.

5. Number of employees during peace time, distinguishing between male and female.

6. Number at present employed.

7. Generally, any further particulars which in the opinion of the concern are necessary or may assist in the aim of the Organisation, viz., Complete statistics of the Small Firms with a view to their exerting their influence as a unit. The Firms are invited to use their individual discretion in this respect as particulars will be treated confidentially. ED. THE E.]

BOOKS RECEIVED

The "Welding Review" Year Book, 1940. Petts Wood: 18, The Covert. Price 2s. 6d. net.

Iron and Steel To-day. By J. Dearden, B.Sc. London: Oxford University Press, Amen House, Warwick Square, E.C.4. Price 4s. 6d. net.

A Handbook of Home-Grown Timbers. Second edition. London: His Majesty's Stationery Office, York House, Kingsway, W.C.2. Price 2s. net.

The Theory of Structures. Fourth edition. By C. M. Spofford. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 40s. net.

Internal Combustion Engines. Fifth edition. By L. C. Lichty. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 30s. net.

Organization and Management of Production. By W. N. Mitchell. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 26s. net.

American Diesel Engines. Second edition. By L. M. Morrison. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 33s. net.

A Handbook of Empire Timbers. Edited by H. A. Cox, M.A. London: His Majesty's Stationery Office, York House, Kingsway, W.C.2. Price 3s. 6d. net.

Public Speaking for Technical Men. By S. Marion Tucker. London: McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 20s. net.

Marking-Out for Machinists. By Captain Richard Twelvetrees, A.M.I. Mech. E. London: Percival Marshall and Co., Ltd., 60, Kingsway, W.C.2. Price 1s. 6d. net.

The Physical Examination of Metals. Vol. I. Optical Methods. By Bruce Chalmers, B.Sc., Ph.D. London: Edward Arnold and Co., 41 and 43, Maddox Street, W.1. Price 14s. net.

Practical Shop Mathematics, Volume 2, Advanced. By J. H. Wolfe and E. R. Phelps, Ph.D. London: McGraw Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 13s. 9d. net.

Water Supply and Sanitary Engineering in 1939

IN this article some brief notes are given regarding works of water supply and sanitary engineering carried out by the larger municipalities and other authorities. Though it is difficult to gather precise information it appears that, apart from a slowing down of the progress of work owing to difficulties of supply, few works which had actually been begun before the outbreak of war have been abandoned. Certain of the more important water supply schemes, notably Haweswater and Ladybower reservoirs, were fully described in our article entitled " River Control and Water Storage in 1939 " which appeared in a previous issue.

London.—At the Northern sewage outfall works, Beckton, the extension of the aeration and reaeration channels of the activated sludge plant was completed, and is now in operation. Eight circular settling tanks each 95ft. in diameter and 12ft. deep were under construction. Three of these tanks are now in operation, and the remainder should be completed and ready for use this year. The reorganisation of the engine house to accommodate new turbo-blowers, electric generators, and boilers fired by sludge gas was completed. The construction of detritus pits for removing the sand, &c., from the whole of the sewage and storm water flowing to the Northern outfall works was proceeding. At the Southern outfall works, Crossness, work was in progress in connection with the installation of electrically driven mechanical sludge scrapers in one of the six precipitation channels, and the raising of the weirs in all channels. Also, at this outfall, four additional centrifugal pumps driven by oil engines were being installed in an existing engine house. These pumps will increase the pumping power at the works by some 500 tons per minute. During the year the improvement works on the Beverley and Pyl Brooks carried out by the Surrey County Council were completed. The Eltham relief sewer and the extension of the Brook Green branch of the Hammersmith storm relief sewer were both completed during the year, and are now in operation. Work on the Earl storm relief sewer and the Earl pumping station was proceeding, and the construction of the sewer should be completed this year.

Belfast.—As a result of the Belfast Water Act, 1938, which added some 32 square miles to the Statutory district of supply, this year has been one of activity in the matter of extending the distribution system so as to supply the increased area. The principal construction work, which was started at the beginning of the year and is still in progress, is a contract—placed with McLaughlin and Harvey, Ltd.—for a filter house, low level service reservoir of 3,000,000 gals. capacity, high level service reservoir of 600,000 gals. capacity, all in reinforced concrete, together with ancillary works. Rapid gravity filtration plant and sterilisation apparatus to deal with one million gallons per day was being installed by the Turn-Over Filter Company, Belfast, and two electrically driven centrifugal pumps of 130 H.P. each are being supplied by the Harland Engineering Company, Ltd., of Alloa. In connection with this work, some 8 miles of distribution mains, 15in. diameter to 4in. diameter, were laid by direct labour. Another new area, on the south side of Belfast, necessitated the laying of about 5 miles of pipes, in diameters from 9in. to 4in. The laying and repairing of all communication pipes is now carried out by the Board—since April 1st, 1939. The chief assistant engineer, Mr. John S. Dalzell, died very suddenly in September, and Mr. Richard H. McCullough, B.Sc., Assoc. M.I.C.E., has been appointed deputy engineer as from December 1st, 1939.

Birmingham.—The additional length of water mains laid in the area of supply was somewhat less than in former years owing to the fact that during the last few months of the year building operations were suspended and new supplies were not, therefore, in demand to the same extent. The total length of supply mains laid during the year amounted to about 60 miles. The construction of the third line of pipes on the Elan Aqueduct from Wales was completed during the year. It consists of a 60in. concrete-lined steel main, and it has been laid by instalments during the last 20 years according as the demand for water in the area of supply has gradually been increasing. A new 36in. concrete-lined steel main was being laid from Highters Heath reservoir to Solihull for improving the supply in the latter district on the Middle Level Zone. The total length of this main is 5½ miles and about 3⅔ miles are now complete. A further 2 miles of 15in. cast iron main was laid in the urban district of Solihull.

The construction of the new covered service reservoir at Perry Barr, near the northern boundary of the City made good progress during the year. This reservoir is designed to act as a balancing factor on the Middle Level Zone, and is supplied by gravitation from Frankley, about 10 miles away. The capacity of the reservoir will be 18,000,000 gal. and the average depth of water about 18ft. The whole of the concrete walls, which form the periphery of the reservoir, were completed, and the earthwork banks which support them externally were also formed. Nearly the whole of the concrete floor was laid, and about 74 per cent. of the number of supporting pillars for the roof are in position, while about half the roof proper was formed. At Edgbaston pumping station the old steam plant, which has supplied the Hagley Road zone for a great number of years, was dismantled, and new electrically driven pumps were being installed to deliver water in future into the Northfield and Warley zones of supply.

Preparations are in hand for the installation of a new electrically driven booster pump at the Highters Heath reservoir for improving the pressure in the southern portion of the district of supply.

In connection with Air Raid Precautions, work was proceeding on the laying of a new 24in. concrete-lined steel main for the greater protection of the central portion of the City in the event of fire. The main will be supplied with water at the pressure obtained in the Northfield zone. A new 15in. cast iron main is being laid between the districts supplied by Birmingham and Coventry.

The reconstruction of the Rea Valley main sewer from Macdonald Street to Sir Harry's Road is now nearing completion. The work consisted of the construction of over a mile of 72in. and 69in. diameter sewers in open cut with a short length under private property which was constructed in heading in cast iron segments with blue brick lining, the estimated cost being £77,000. The contractors were Cameron and Pooley, Ltd.

The Babbs Mill to Gressel Lane and Mackadown Lane outfall sewerage scheme for providing sewerage facilities for an industrial area and future housing development at Kitts Green was completed by Currall, Lewis, and Martin, Ltd., the estimated cost being £39,000. The work consisted of about 3200 yards of foul and surface water sewers varying in size from 33in. to 15in. in diameter with a 7ft. by 4ft. flat-topped culvert, constructed in open cut with the exception of a short length under railway property, which was constructed in 33in. diameter superimposed on 18in. diameter cast iron pipes in heading.

The Bartley Green sewerage scheme for sewering an area to be developed as an housing estate and other developments was being carried out by Cameron and Pooley, Ltd., of 210, High Street, Erdington, Birmingham, the estimated cost of the first section being £24,900.

The work consists of the construction of approximately 2000 yards of foul water sewer varying in size from 27in. to 36in. in diameter, mainly in open cut with a short length constructed in heading.

Bradford.—During the year the connecting sewers joining the Guiseley district of Aireborough to the Esholt works were under construction, in addition to which, agreement was arrived at with the Shipley Urban District Council to take the sewage of this township into the Esholt works. The inclusion in the Esholt works of all the important textile effluents of this woollen centre is thus completed. The additions increased the dry weather flow to the Esholt works to about 20 million gallons per day, and included the gas liquors of both Bradford and Shipley.

Extensions to the press house were under construction, increasing the number of presses from 128 to 160. The treatment of the sewage from this area during war time is a heavy responsibility, particularly because of the very large amount of wool washing and the dyeing of khaki and other cloths wherein sulphur dyes are used. There was and is, however, a very big demand for the department's products, which are likely to realise during this financial year a very large sum. The by-products of the department embrace recovered greases, improved types of wool grease, soap materials, paint materials, and sterile organic fertilisers, of which very large quantities are sold. In connection with the acid plant, an interesting electrical precipitator was erected for the elimination of dust. It is hoped thereby to take out about 97 per cent. of the dust from the gases.

Corby (Northants).—The construction of the Eye Brook reservoir was continued throughout the year, and the embankment and works incidental thereto are approaching completion. Impounding commenced on December 4th. Work was started on the laying of the pipelines and the construction of the two water towers. Orders were placed with Mather and Platt, Ltd., for the pumping installation, and with the Paterson Engineering Company for the equipment of the purification plant. The joint engineers for the scheme are Messrs. Binnie, Deacon, and Gourley, and Messrs. Herbert Lapworth Partners, and the resident engineer is Mr. A. R. Ellison, M.I.C.E. The contractors for the water towers are Holst and Co., Ltd.; the reservoir and pipelaying work are being carried out by direct labour.

Edinburgh.—Most of the work done during the year was in connection with air raid precautions. A large bye-pass water main was laid round the eastern side of Edinburgh so that the water can be supplied to the eastern side of the city in the event of any damage to the important filtering station at Alnwickhill or to the four mains which convey the water from the filtering station to the eastern side of the city. Over 100 additional valves were placed on the leading mains to divide them into shorter sections so that in the event of any damage the water could be cut off a shorter section than previously. The total cost of the work carried out for A.R.P. purposes is estimated at £27,000, part of which is being met by a Government grant.

Glasgow.—To effect an improvement in the northern portion of the City, which is situated at a height above the service reservoir at Milngavie, a new reinforced concrete reservoir and high tank was being erected which will augment the existing storage reservoir situated in Springburn Park. The capacity of this new structure will be 2¼ million gallons, 1¼ million gallons in the reservoir, and 1 million gallons in the high tank, which is 50ft. above ground level. The whole structure is rectangular in shape, being 170ft. long by 90ft. broad, and is divided into two portions separated by a vertical joint ½in. wide filled with Bitumastic sheeting. Each unit is complete, having a separate inlet and outlet to the high and low tanks. Access to the high tank is by means of a concrete stairway leading to the roof of the high tank, and a manhole and wrought iron ladder into the tank. The reinforcement is mild steel round bars from 1½in. diameter to ⅜in. diameter. The concrete in the floors, roofs, and columns is composed of 1 : 2 : 3 mixes, and the walls of reservoir and tank 1 : 2 : 2 mix. The coarse aggregate for thickness of 18in. or more is graded from 1in. to ¼in., the remainder of the work from ⅜in. to ¼in. The tests specified were :—

1 : 2 : 2 mix.	2500 lb. per sq. in. at 7 days.
	4000 lb. per sq. in. at 28 days.
1 : 2 : 3 mix.	2000 lb. per sq. in. at 7 days.
	3500 lb. per sq. in. at 28 days.

On test these figures were exceeded. The work has been in progress since May of last year, and should be completed by the late summer of the present year.

The extension of the main drainage system which was begun three years ago proceeded vigorously during the year. About 5000 yards of sewers, varying in diameter from 3ft. to 7ft. 6in., were completed. The contracts let prior to the outbreak of hostilities are being carried on without serious impediment, although on all but one night-shift work had to be abandoned.

Horsham.—The modernisation of the existing purification works was completed during the year at a cost of about £13,500. The work included a plant for the disposal of sludge, using the Porteous process. The consulting engineers were Messrs. J. D. and D. M. Watson, of Westminster.

Liverpool.—In order to meet the demands of the developments in the Speke and Garston districts, it has been found necessary to provide a new service reservoir. This reservoir is of reinforced concrete, with a capacity of approximately 3 million gallons, and is covered. The construction

has been carried out by Morrison and Sons, Ltd., of Liverpool. Work on the site commenced in July, 1938, and the reservoir was finally completed in November, 1939. During December it was tested and put into commission.

The supply to the northern part of the compulsory area of supply, which includes important docks areas, Boroughs of Bootle and Crosby, and various District Councils, has hitherto been given from branch mains off the trunk mains which travel directly from the Prescot reservoirs to the centre of Liverpool. The continuous developments which have been taking place in the outskirts of the City and district, both industrially and for re-housing, have proved an increasing burden on the existing supply mains to the northern area. In January, 1939, it was decided to lay a new trunk main to relieve the existing supply mains, and to provide some reserve for the future. The main will be 42in. internal diameter, of steel tubes sheathed and lined with bitumen, beginning at the Prescot reservoirs, some 8 miles from Liverpool, and travelling in a north-westerly direction for a distance of approximately 7 miles. On reaching the boundary of Liverpool, the 42in. trunk main will be divided into two branch mains, each 30in. internal diameter, both of which will ultimately terminate at two service reservoirs lying within the area to be supplied. The laying of the 42in. main was commenced during August, 1939, and, up to the end of December, 33 per cent. had been laid. The pipelaying is being carried out by Leightons (Contractors), Ltd., the steel pipes are being supplied by the South Durham Steel and Iron Company, Ltd., Stockton-on-Tees, and valves by Guest and Chrimes, Ltd., Rotherham. The estimated total cost of the work is £160,000.

Luton.—Work was proceeding steadily on the main sewer and the new sewage purification works. The sewer has been designed for a population of 150,000, while the works will treat the flow from a population of 120,000, provision being made for future extensions. Further works, such as buildings and special plant, were in course of construction, and it is estimated that the work will be finished by about July, 1940, at an approximate cost of £370,000. The consulting engineers are J. D. & D. M. Watson, of Westminster.

Manchester.—On the Thirlmere aqueduct the existing copper gauze strainers at Horwich were replaced by six Peebles rotary strainers 7ft. 6in. in diameter, each capable of passing 10 million gallons per day through 100 mesh to the inch wire-cloth. In the distribution area, a new booster station consisting of six vertical spindle electrically driven pumps of a total capacity of 10,000 gallons per minute was put into operation to maintain the pressure in the North Cheshire area. Chloramine plants automatically proportioning the dose to the draw-off were installed at the outlets of the four largest service reservoirs.

Main drainage work, No. 6, was commenced last year, and consisted of approximately 2000 lineal yards of a 6ft. 3in. brick barrel sewer at an average depth of 60ft. The approximate cost was £56,000. Sewers for the relief of flooding in North Manchester were completed. The sizes varied from 9in. pipes up to a 4ft. 3in. diameter brick sewer. The estimated cost is £22,000. A 9in. drain was laid from Baguley sanatorium to the Western intercepting sewer at a cost of approximately £3100. A relief sewer in Moston Lane East, varying in size from 12in. to 21in., at an average depth of 16ft., was completed. The cost was approximately £5200.

Middlesex County Council.—Work was proceeding on the construction of the Hampton branch sewer which is to link up existing sewage works at Hampton to the West Middlesex main drainage system, and is expected to finish by about April, 1940, the estimated cost being £36,000.

The East Middlesex main drainage scheme covers some 33 miles of main sewers and purification works for a population of 800,000. The Parliamentary estimate for the work was £2,700,000 and the work was expected to be finished in about 5 years. Several contracts were let and work was started, but it was subsequently suspended on account of the war. The consulting engineers are J. D. and D. M. Watson, of Westminster.

Peterborough.—Work has been proceeding on 14 miles of main sewers and the construction of the purification works. The value of the two contracts is £250,000, but work has been suspended on account of the war. The consulting engineers are J. D. and D. M. Watson, of Westminster.

Plymouth.—Work proceeded steadily on the construction of new sewage purification works to provide for a population of 30,000 and was completed at a cost of approximately £85,000. The consulting engineers are J. D. and D. M. Watson, of Westminster.

Rugby.—Contracts for both the Northern and Southern Area water supply schemes in the Rural District were let and work was proceeding on both. The estimated cost of the two schemes, involving some 35 miles of pipe line, is £44,000.

Southend-on-Sea—The Shoeburyness and Eastern Area sewerage scheme, comprising about 7 miles of sewers and 4 new pumping stations, was designed to convey sewage from the Shoeburyness area to the Corporation's existing disposal works at Prittlewell. The work was practically completed at an approximate cost of £140,000 The consulting engineers are J. D. and D. M. Watson, of Westminster.

We have also received the following note regarding work going on abroad.

Rangoon.—Work proceeded actively by direct labour during the year on the construction of the 14,800 million gallon Gyobyu reservoir on the Pegu Yomas and the embankment is about 85 per cent. completed. The fabrication and lining at the local factory of the 43 miles of 56in. internal diameter concrete-lined steel pipeline to convey the water to the Corporation's existing Kokine reservoir was continued, together with the earthwork formation for the pipe trench and railway track for pipe transport, and the construction of the concrete pedestals on which the pipes will be supported. About 60 per cent. of the pipeline has now been laid. Some 1500 men are employed on this scheme. The work is being carried out to the designs and under the direction of Messrs. Binnie, Deacon, and Gourley, with the collaboration of Mr. A. E. Mann, M.I.C.E., the Engineer to the Corporation, the Chief Resident Engineer being Mr. E. C. Steer, B.Sc., M.I.C.E.

Precision Optical Apparatus

IN the course of a recent visit to Leicester we had an opportunity of inspecting a number of the wide range of electrical and optical precision instruments being made at the works of Taylor, Taylor and Hobson, Ltd.

ELECTRICAL LIMIT GAUGES

The first of these instruments inspected was the "Electrolimit" gauge shown in Fig. 1, which measures by mechanical contact, the readings being electrically magnified. It has the particular advantage of being adjustable for large magnification, and is subject to no detrimental wear, which enables it to be used in the inspection of mass production parts to a degree of accuracy normally obtainable only with master gauges. This instrument is made in two sizes, the smaller for work up to 4in., and the larger for that up to 10in. in height. As may be seen, it consists of a substantial base into the surface of which is let a serrated hardened steel anvil. A rigid cylindrical steel pillar set in the base behind the anvil carries an adjustable

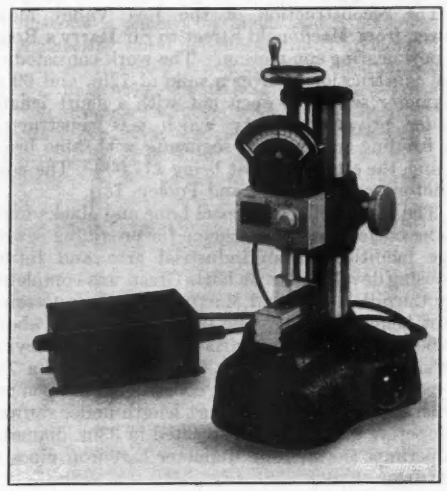


FIG. 1—"ELECTROLIMIT" GAUGE

bracket on which is mounted the electric measuring head and micro-ammeter assembly. The bracket is moved up and down the pillar by a hand wheel operated lead screw. Protruding from the base of the electric head is a diamond pointed spindle which contacts with the workpiece on the anvil. The upper end of this spindle makes contact with a steel lever armature, spring mounted centrally between two coils forming half of an A.C. bridge. The slightest end movement of the spindle by the work deflects the armature, thus unbalancing the bridge circuit, and the amount of displacement is indicated on the scale of the micro-ammeter. A separate power unit contains two other inductances of the bridge circuit together with a voltage regulator, a 10 to 1 transformer and a rectifier which supplies the D.C. current for operating the micro-ammeter. The range of magnification with these instruments is from about 800 to 1, to 13,000 to 1, giving full scale readings for 0·004 to 0·00025in. Thus with a full scale 3½in. long, having 60 divisions, each easily capable of being divided into half, at a magnification of 13,000 to 1, the full scale reading will be 0·00025in. Hence one small division will be $\frac{0{\cdot}00025}{60} = 0{\cdot}0000042$ or approximately 4 millionths of an inch.

The 4½in. scale, having the same number of divisions, but being more open will enable millionths of an inch to be estimated fairly readily.

The instruments are set to master gauges and by means of a knurled knob, set in the base, the pointer of the micro-ammeter can be adjusted to the required fraction on the scale.

When it is required to test cylindrical parts, the anvil is easily removed and replaced by a Vee block. If it is necessary to gauge work on a surface plate, the head can be swung round on its column and its overhang from the rear of the base is sufficient to give a reasonably good range.

An internal gauge works on a similar principle for the measurement of holes in components. This instrument not only accurately and rapidly checks diameters of the holes, but also detects any variations, such as taper and out of roundness. It is made in two sizes, with spindles from ½ to 1¼in. diameter and 1½ to 3in. diameter, and works limits similar to those of the external type of instrument. Although these instruments work to such high limits of accuracy, they are strong and can stand any reasonable amount of vibration without depreciation of their standards.

Another form of these gauges is designed for the continuous measurement of strip materials such as metal, paper, rubber, &c., as they pass from their rolls. For the measurement of cylinder bores and other types of holes where it is not practicable to use a stationary instrument, portable gauges working on the same principle are made.

PROFILE PROJECTOR

A compact profile projector, having a horizontal screen, which the company is now making is shown in Fig. 2. This projector covers a floor space of only 11ft. 6in. by 7ft. 6in. and is under 12ft. in height. It has a projection length of 200in., and its optical combinations give magnifications from twenty to one hundred times the size of the original, the focal lengths being from 2 to 10in. The fabricated steel frame carries a 5ft. diameter screen, built up of hard wood sections and covered with a one-piece veneer, which is held in the frame by twelve adjusting screws. This screen can be swung in a horizontal plane through an angle of 10 deg. on either side of normal to provide a convenient means of locating the template, or enlarged drawing, in relation to the image.

A filament type projection lamp is used and is prefocused, to avoid the necessity for adjustment when a change is made. The work table, which has a ⅝in. inverted T slot, is 12in. long by 4in. wide, and lies 6in. below the optical axis, there being a 2ft. clearance above the axis to admit large work. In operation a beam of light passes an achromatic condenser lens and illuminates by collimated light the profile of the work. Thence the beam passes through a projection lens and the image of the profile is reflected upwards by an inclined mirror to an overhead mirror in the top of the frame, which reflects the magnified image down on to the horizontal screen. On each side beneath the screen are handwheels which work the focusing and positioning controls so that the operator can control the position of the image on the screen without leaving his position.

ALIGNMENT TELESCOPE

An interesting apparatus designed for the setting up of such things as the assembly jigs of large aeroplane wings, the lining up of bearings and long shafts, &c., is the alignment telescope shown in Fig. 4. It consists of two units, the telescope and a collimator. The arrangement of the units is shown in Fig. 3. The telescope comprises an eyepiece A, which is focused upon a graticule B to suit the vision of the observer. The graticule carries two lines at right angles, their point of intersection being accurately positioned on the axis of the telescope. An image of the object under observation is focused in the plane of the graticule by movement of the lens C by a knurled knob. The telescope is constructed so that its mechanical and optical axes are coincident within very fine limits. For observations of dis-

placement an image of a scale carried by the target plug or by the collimator unit is formed on the graticule by racking the lens forward. The graticule and the super-imposed images are observed by means of a microscope system incorporated in the telescope and the apparent and real displacements of the object with the same orientation and the unit carries a spirit level G. When the bubble of the spirit level is set to the zero mark each graticule has one series of divisions horizontal and one series vertical, thus enabling systematic observations of displacement and tilt to be made in two meridians at right angles.

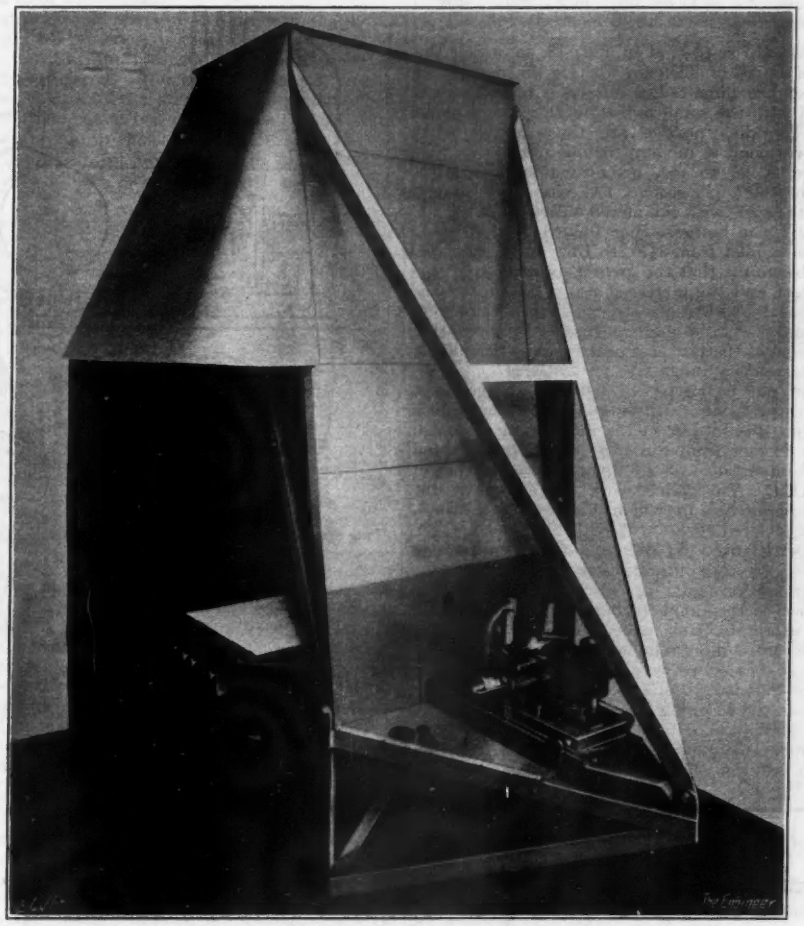


FIG. 2—PROFILE PROJECTOR

off the telescope axis are not inverted and are in the same direction.

The construction of the collimator is similar to that of the telescope to ensure coincidence of the mechanical and optical axes. In it a graticule D, Fig. 3, is mounted in the focal plane of the collimator lens E. Behind this graticule is mounted a 4-watt lamp and light from it passes through a diffusing disc and condensing lens. Light from each point of the graticule leaves the lens E in a parallel or collimated beam and the graticule is virtually at infinity. The graticule carries a central star, accurately positioned on the axis of the collimator, and scales are arranged symmetrically around. In these scales each small division represents an angular displacement of half a minute of arc.

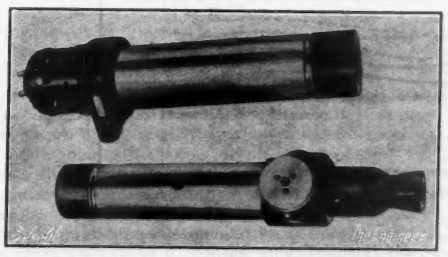


FIG. 4—ALIGNMENT TELESCOPE AND COLLIMATOR

For the measurement of displacement the collimator carries a sighting target F, shown in Fig. 5, mounted in front of the lens. The arrangement of this target is similar to that of the graticule D but its units are in inches, each small division representing 0·01in. The target and the graticule are mounted

Sighting targets are also supplied mounted in separate plugs for the purpose of making displacement measurements only. A number of these plugs may be used for setting a series of bearings in the same plane.

It is claimed that when using the telescope and collimator no difficulty will be found in measuring the relative tilt of a pair of bearings to within one-fifth of a scale division of 6 seconds of arc, and that this accuracy can be maintained at separations of 100ft. in still air. The maximum amount of tilt measurable is about 30 minutes of arc, whilst the extended collimator field enables an image to be picked up at inclinations of 2 deg. It is possible to measure a lateral displacement of a pair of bearings to within 0·01in. at 50ft. and correspondingly better at shorter distances. The actual amount of displacement or tilt is measured by the position of the imaged scales relative to the central cross of the telescope graticule, but considerably smaller errors are detectable by observation of the displacement of the vertical or horizontal lines of the cross from the central star of the graticule images.

A line can be set into a V to great accuracy and amounts to tilt or displacement may thus be detected even when too small for their actual magnitude to be measured. For this purpose the telescope graticule carries a simple cross while the accuracy graticules carry a central star consisting of four V's of small angle arranged at every 90 deg. This apparatus has a wide field of application, and its portability and accuracy are combined with a robust construction which suits it for general use in workshops.

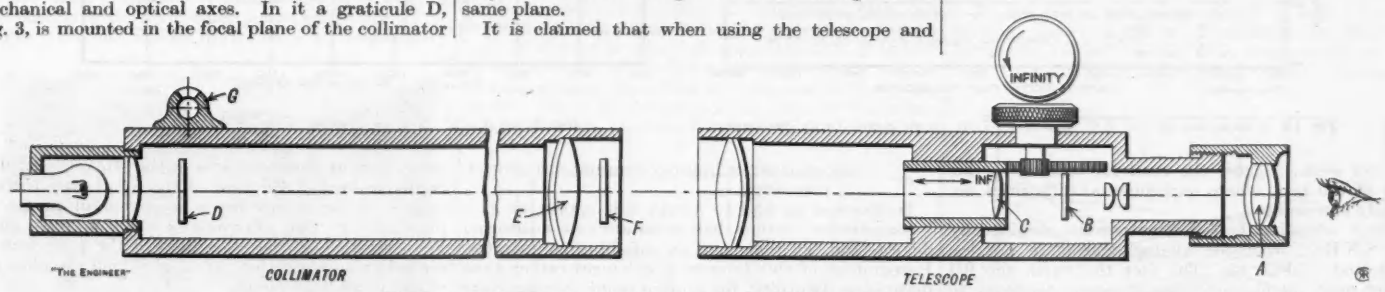


FIG. 3—ARRANGEMENT OF ALIGNMENT TELESCOPE AND COLLIMATOR

SECTION PROJECTOR

The company has designed an ingenious machine for the purpose of obtaining sections of work which cannot be projected with the normal profile projector, as for example an axial section of a thread having a large helix angle, or a worm wheel, or helical bevel gear. This machine has not been placed upon the market, and is at present being used for consultant purposes only. It comprises a table over which is mounted an adjustable head carrying a light projector and a camera. The work is held on the table of the instrument which is provided with motions for selecting and recording any desired plane in which the section is required. The outline of the desired section of the work is produced by means of a sheet of light which is formed by a special illuminating system and is thrown on to the work in the direction in which the section is required, the sheet of light constituting the section plane. The line of light formed by the intersection of the tooth with the plane traces the required plane section, and this is photographed by means of the camera, the lens of which can be positioned to view the section from a suitable oblique view point. For pinion teeth that are undercut at the roots two view points may be required—one for each flank. The camera has a specially devised lens system the geometry of which is such that despite the obliquity of view and the movement from one view point to another, the resulting unit size photograph is free from distortion and is sharply defined all over the plate.

An eye-piece is provided as a "finder" for setting up, but actual measurements are made from the photographs which are identical in size with the object. To obtain good contrast the surface of the work is sometimes coated with a very thin film of white paint, about 0·0001in. thick.

We are informed that the company is prepared to offer a consultative service to manufacturers who have problems which they think could be solved by the aid of this instrument. This service consists in providing a photographic negative, actual size, of the required section (not exceeding an elliptical area 0·7in. by 1in.) forming part of the gear or other object not exceeding 20in. in diameter. A drawing can also be provided having an enlargement of 30 or 50 times but not exceeding in size 15in. by 20in.

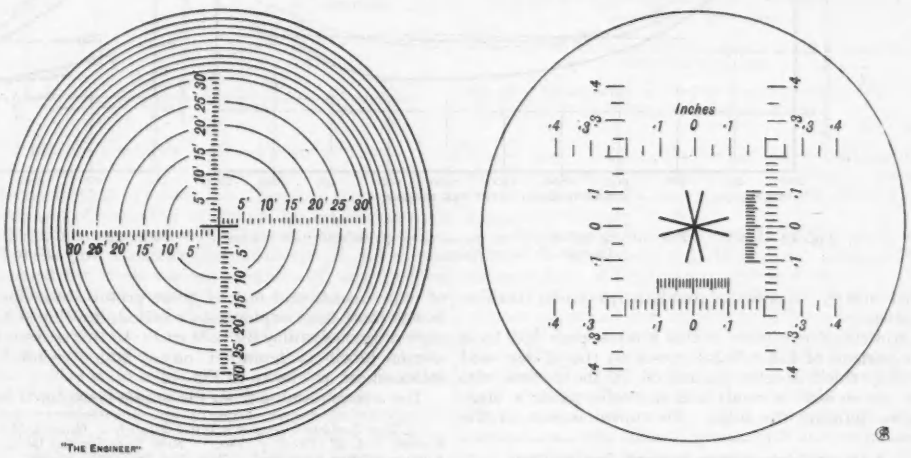


FIG. 5—SIGHTING TARGETS OF COLLIMATOR

Some Researches on Steam Turbine Nozzle Efficiency*

By HENRY LEWIS GUY, D.Sc., F.R.S., M.I.C.E.

No. II

(*Continued from page 73, Jan. 19th*)

APART from the deduction from tests with actual turbines designed with different steam-velocities, re-examination of the S.N.R.C. tests together with a mass of later information gained from continuous researches with this and other types of apparatus, suggests that, whilst the true characteristic of certain types of nozzles may be of waved form, as shown in Fig. 6, *ante*, the actual rise and fall of efficiency with velocity, particularly at low velocities, is much less than these tests suggest. Further, for other nozzle-types the variation of efficiency with velocity follows quite different characteristics, and to some extent the shape of the characteristic can be controlled by design.

In experiments of this kind, apparatus errors and shortcomings in test technique are often characteristic of a particular apparatus and method of test.

This is illustrated by the curves shown in Fig. 10, in which the result of tests in our own nozzle-tester of the S.N.R.C. type with the original S.N.R.C. straight "Mellanby nozzle," and also with the original S.N.R.C. 20-deg. thick flat-chamfered nozzle, which we borrowed for this purpose, are contrasted with the results on the same nozzle published in the S.N.R.C. reports. In order to simplify comparisons of these two determinations of the shape of the characteristics, our own curve, which gave slightly higher coefficients, has been moved vertically downwards in Fig. 10 until the two coincide at velocities of 800ft. per second for the 20-deg. nozzle and of 900ft. per second for the straight nozzle.

In both cases it will be noted that the rise of efficiency at low velocities is much less marked in our test than in those of the S.N.R.C. Again, if the results of the S.N.R.C. tests on straight nozzles are examined, as replotted in Fig. 11, the steep rise at low velocities, which implies efficiencies of over 100 per cent., suggest the need for caution in this area of the test, where experimental difficulties are rapidly increasing.

Again, consider the significant results obtained by the S.N.R.C. with the 20-deg. thin-plate nozzles, re-plotted in Fig. 12. The fact that with the 0/1 throat-ratio the characteristic shows no tendency to rise at low or high velocities, is of great importance, for of this group the 0/1-ratio nozzle is the one which most nearly represents modern practical turbine nozzles.

Additional evidence of this kind is provided by a comparison of the S.N.R.C. tests on the 12-deg. and 20-deg. thick nozzles chamfered at the outlets, the one series with a small and the other with a large radius forming the inlet. The mean curves of the observation are re-plotted in Fig. 13, in which the absence of the rise of efficiency with low and decreasing velocity of the large-radius nozzles is most marked compared with the small-radius nozzles; once again these large-radius nozzles are those which most nearly correspond to modern turbine nozzles.

Further, it is, to me, inconceivable that, at a velocity of 400ft. per second, the losses in a 20-deg. thick-plate nozzle with chamfered outlet and a throat-ratio of 3/1, can be more than halved by decreasing the radius at inlet from 1¾in. to 1in. It is, however, conceivable to me that the greater experience in this kind of test and the increased use of the apparatus at the later date when the larger radius nozzles were tested, resulted in a more accurate determination of the shape of the nozzle characteristic at the lower end of the velocity range.

It must not be supposed that such suggestions, made many years later with the guidance of continuous research on this subject in the intervening years, in any way detract from the very great practical and historical importance of the invaluable researches of the S.N.R.C. This later work arose out of the S.N.R.C. researches, by which it was directly stimulated and inspired.

Work with this kind of nozzle-testing apparatus emphasised the kind of limitations in its utility which the previous discussion reveals, and the recurrent appearance of certain disturbing anomalies resulted in many attempts being made to improve it, so as to make the results more reliable and absolute.

Amongst these steps were :—

(*a*) The substitution of knife-edges for ball bearings on the weighing arm attached to the impact-plate.

(*b*) Improvements in the form of cage.

(*c*) The addition of baffles in the neighbourhood of the exhaust, to improve pressure-distribution in the casing.

In the end we had to accept this apparatus as a "comparator" rather than as an absolute measuring device, and, at that, not an infallible comparator. Recognition of this limitation enhances rather than diminishes its utility, for it often tends to exaggerate or caricature the effect of differences in vane-forms.

A search was naturally made for alternative methods of experiment, and one of great promise was found in the pitot-tube exploration method, developed to a high degree of utility by L. Wirt.[4] In this system the nozzle block is mounted on a large "wind" or steam-chest, as shown in Fig. 14.

The stream issuing from the nozzle is explored by a minute pitot-tube in a plane parallel to the outlet face of the nozzle and at a standardised distance from it, equal to the clearance usual between the nozzle outlet and the inlet of the moving blades. The distribution of the losses in the nozzles is deduced from such pitot readings and those on the upstream side, and by integrating over the whole exit face the nozzle-efficiency can be deduced.

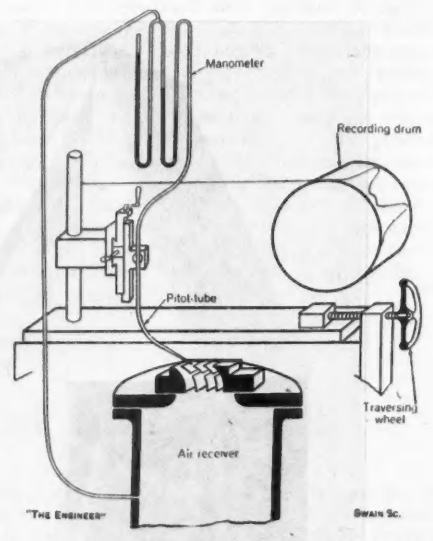


Fig. 14—*Diagrammatic Arrangement of Small Pitot-Tube Apparatus*

It is necessary in this form of test to take a very large number of separate observations, particularly near the boundaries of the stream. As many as three hundred per nozzle is quite common and necessary if accurate results are to be obtained.

The axis of the pitot-tube must point in the mean direction of the stream from the nozzles, so that, as in the S.N.R.C. type of nozzle test, the direction of steam-flow at various points in the stream must first be determined. For tests on these full-scale turbine nozzles a vane provides a more useful means of plotting out the efflux-angles than a yaw-meter. For convenience, the movement of the pitot-tube is geared up to a rotating drum, on which the observer plots his readings direct.

Such a series of observations permits contour maps of the losses to be plotted, and from such contour maps a solid model of the distribution of the losses can be constructed, as shown in Fig. 15, as well as a complementary solid model of the distribution of efficiency, as in Fig. 16.

In examining the latter model, it is, I think, notable how closely certain characteristic "ripples" in the value of efficiency at various parts of the stream are reproduced in each of the nozzle passages.

Again, the concentration of the losses at the

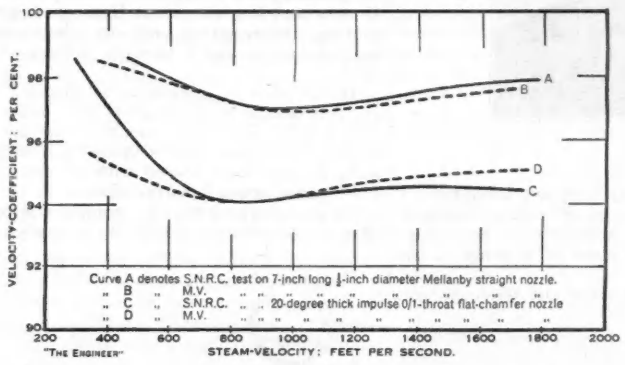

VELOCITY-COEFFICIENT: PER CENT.
STEAM-VELOCITY: FEET PER SECOND.
"THE ENGINEER"
Curve A denotes S.N.R.C. test on 7-inch long ¼-inch diameter Mellanby straight nozzle.
" B " M.V. " " " " " " " " " "
" C " S.N.R.C. " " " 20-degree thick impulse 0/1-throat flat-chamfer nozzle
" D " M.V. " " " " " " " " " "

Fig. 10—*Comparison of S.N.R.C. and M.V. Tests on the Same Nozzle Specimens*

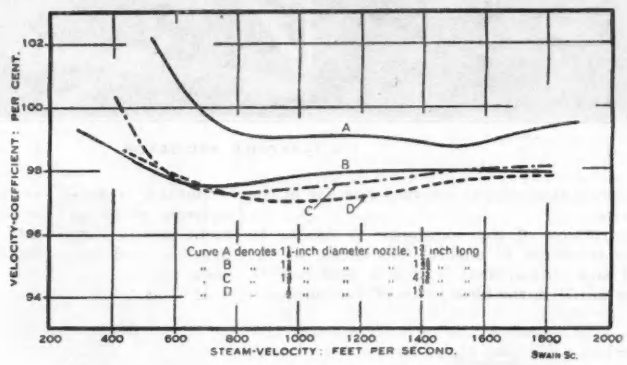

VELOCITY-COEFFICIENT: PER CENT.
STEAM-VELOCITY: FEET PER SECOND.
SWAIN SC.
Curve A denotes 1¼-inch diameter nozzle, 1¾ inch long
" B " 1¼ " " " 1⅛ " "
" C " 1¼ " " " 4½ " "
" D " ¾ " " " 1½ " "

Fig. 11—*S.N.R.C. Tests on Straight Circular Nozzle*

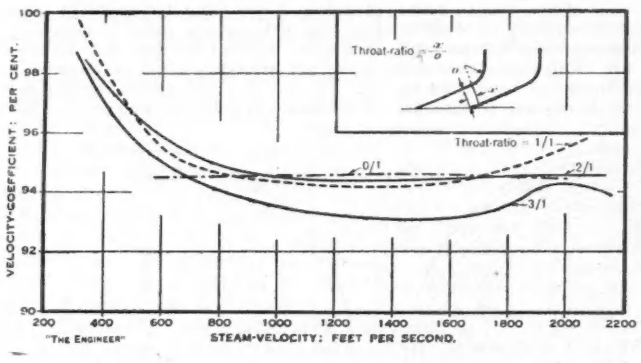


Fig. 12—*S.N.R.C. Tests on the Effect of Throat-Length of a 20-Degree Thin-Plate Impulse-Turbine Nozzle*

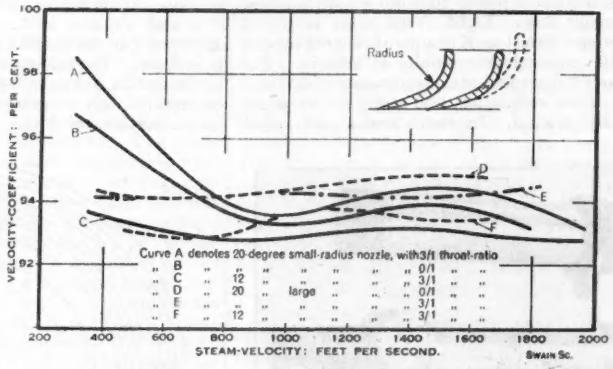

VELOCITY-COEFFICIENT: PER CENT.
Radius
Curve A denotes 20-degree small-radius nozzle, with3/1 throat-ratio
" B " " " " " " 0/1 " "
" C " 12 " " " " 3/1 " "
" D " 20 " large " " " 0/1 " "
" E " " " " " " 3/1 " "
" F " 12 " " " " 3/1 " "
STEAM-VELOCITY: FEET PER SECOND.
SWAIN SC.

Fig. 13—*S.N.R.C. Tests on the Effect of Varying the Inlet Radius of Thick-Plate Chamfered-Outlet Impulse-Turbine Nozzle*

* The Sir Charles Parsons Memorial Lecture, 1939.

[4] "The Turbine Designer's Wind Tunnel." *General Electric Review*, Vol. 27 (1924), p. 780. "New Data for the Design of Elbows in Duct Systems." *Ibid.*, Vol. 30 (1927), p. 286.

boundaries is particularly emphasised by this method of test, which gives the distribution of the losses, whereas the S.N.R.C. type of tests give the average loss for several nozzles.

It will be readily appreciated that with the nozzle discharging to open atmosphere it is much more convenient to make observations with air as the medium than with steam.

Wet steam would be required to show up the streamlines and the presence of "break-away" from the surface. Wet steam, however, has the disadvantage that the particles of water used as "tracers" are so much heavier than the steam which propels them, that it is by no means certain that in a curved stream their path is that of the steam itself.

In order to detect break-away in small nozzles, Mr. B. Hodkinson, who supervised much of this

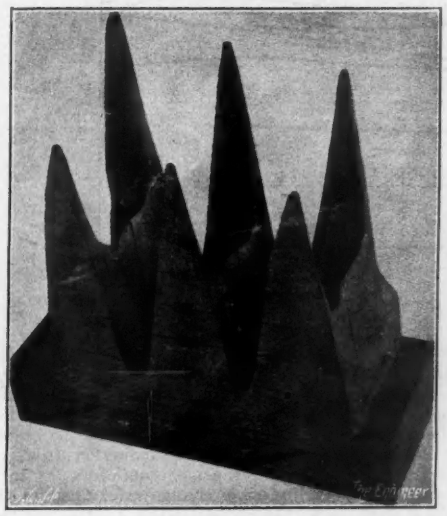


Fig. 15—*Solid Model of Distribution of Losses in Nozzle Passages*

work, devised the use of a small pitot-tube attached to stethoscope ear-pieces, which permits the area of break-away to be traced out by a characteristic change of sound.

A further system of test which has a useful place in these researches is a kind of wind-tunnel experiment, in which the nozzle specimen is reproduced several times full size so that the "Reynolds number" is maintained at a value of interest in turbine work, but with the comparatively low air-speeds usual in wind-tunnel work.

The system of test and a diagrammatic arrangement of this test are practically identical with that of the small pitot-tube apparatus shown in Fig. 14, the change in the main being one of scale only.

Fig. 17 shows the set-up for such a "large-scale"

Fig. 16—*Solid Model of Distribution of Efficiency in Nozzle Passages*

pitot-test. One advantage lies in the fact that the specimen can be made with sufficient accuracy in wood or other readily worked material in advance of the tooling of a new or proposed blade. In the case illustrated, the outer nozzle vanes were aluminium castings from a carefully carved wooden model, whilst the parti-coloured intermediate vane was built up of brass templets spaced by a number of small-bore tubes placed along the median line and filled in with a special cement to the true form.

The composite section of templets, tubes, and cement was used to permit a series of very small holes to be drilled from the surface of the brass templets into the tubes so that the pressure-distribution over the surface could be obtained. In the photograph some of these holes are connected by the rubber bends at the top to a manifold, which in turn allows a very sensitive manometer to be used to measure each pressure separately.

With such observations, diagrams can be constructed giving the pressure-distribution on both sides of the vane in the direction of normal rotation in a turbine, and along what would be the axis of a turbine, as shown in Fig. 18.

In the case of a turbine nozzle or moving blade these curves have quite a different meaning from the "lift-" and "drag-" curves of an aeroplane wing.

The force both in direction of the rotation of the rotor and in an axial direction, resulting from the pressure-difference on a turbine nozzle, is taken directly on the turbine casing and plays no direct part in its operation.

In the case of a moving blade, the force in a circumferential direction resulting from this pressure-distribution provides the torque driving the rotor, whilst that in an axial direction is merely one of the components of thrust which is taken up on the thrust-block.

It is not possible to convert these pressure-distri-

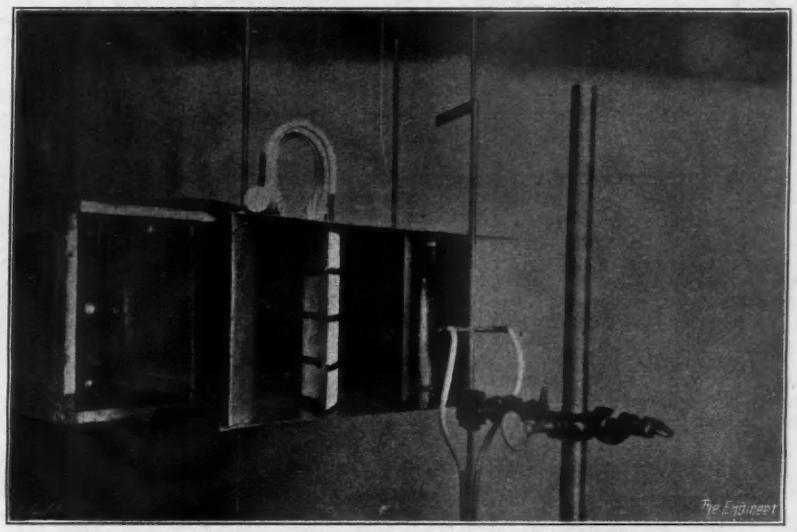


Fig. 17—*Wind-Tunnel Experiment on Large-Scale Model*

butions directly into what is known as nozzle- or blade-efficiency, but they throw some useful light on the condition of the steam at the inlet, and, what is of more importance, also at the outlet.

There are certain considerable limitations in the utility of these large-scale wind-tunnel tests, which emphasise the distinction between usefulness of wind-tunnel work in the case of a turbine nozzle and in the case of an aeroplane wing.

Most wind-tunnel work is conducted with air-velocities which would be very low in a steam turbine and at which the effect of compressibility of the air is not marked, but in the range of velocities used in steam turbines the effect of compressibility is very great. Many of the phenomena peculiar to steam-nozzle flow are controlled by the relation of the exit

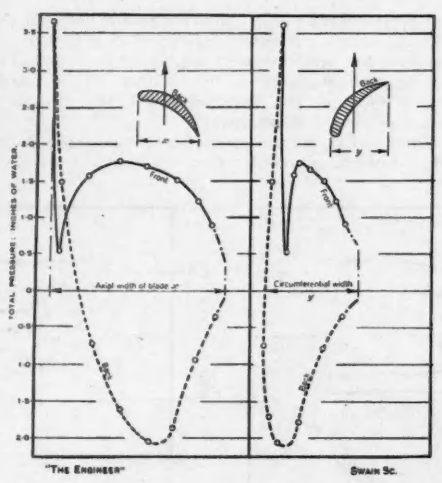


Fig. 18—*Distribution of Pressure over Nozzle Vane*

velocity to that of sound, and therefore the necessary conditions of similarity of flow cannot be co-ordinated by Reynolds number for passages of different scale.

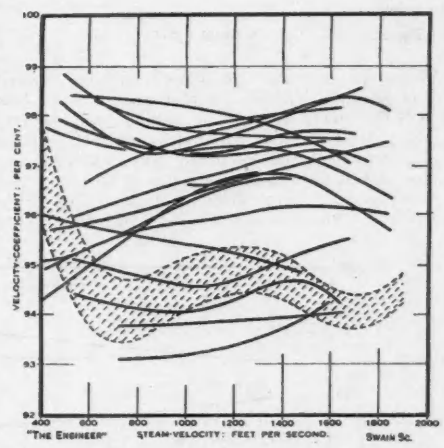
Let us now consider the character of the results obtained by these various methods of experimental attack, and their bearing on one another.

If each method had absolute accuracy, each would, of course, give the same result when used on the same nozzle; the difference between the results for the same nozzle is an index of the extent to which either one or all the methods should be questioned.

At an earlier point I threw some doubt on the advisability of basing principles of turbine design on the shape of the nozzle-efficiency characteristic exhibited in the early tests of the S.N.R.C. One further comment is necessary on the way these tests were made. Whilst both the thick and thin impulse nozzles were well chosen to illuminate extreme characteristics, they were not truly representative of practice at that time, and are basically different from modern designs.

In Fig 19 I have plotted test results for a number of different types of turbine nozzles obtained on our S.N.R.C.-type nozzle-tester, and selected because I have considerable confidence in their general accuracy. In the lower part of the diagram the lightly shaded area between dotted lines reproduces the S.N.R.C. results for the 20-deg. thin-plate nozzle from Fig. 7, *ante*.

It is, I think, notable that none of the characteristics are of the very waved form of the S.N.R.C. curve, and whilst many show a steady rise to an optimum in the neighbourhood of sound-velocity, and some others a rising curve at the lowest velocities, none show anything like the very great rise in efficiency



The shaded band is the S.N.R.C. result for a 0/1-throat thin-plate 20-degree nozzle

Fig. 19—*Characteristics of Various Nozzles Tested by M. V. with an S.N.R.C.-Type Nozzle-Tester*

of the S.N.R.C. curve as the velocity is reduced from 800 to 400ft. per second.

The groups of tests here shown cover a very wide range of designs, most of which have an appropriate place in turbine design. It will, however, I think, be apparent that the form of the characteristic is susceptible to modification by design, and that for each limited range of steam-velocity there is a type of characteristic which gives the best result.

In the main this group of curves falls into two classes. The one has a characteristic which, with increasing velocity, either falls continuously or else falls to a valley at a moderate velocity, thereafter rising very slowly. The other rises continuously with increasing velocity to a maximum, usually below sound-velocity, and thereafter falls with further increase in velocity.

By separating out these results into these broad classes it is possible, I think, to indicate the characteristic of form which typifies them.

The first class is collected in Fig. 20, and all the nozzles concerned are characterised by a sharp inlet and thin body to the nozzle section, and by a wide open entrance. A few examples of this nozzle type are shown at the top of the diagram. The second class, that of rising characteristic, is collected in Fig. 21. The nozzle vanes of this group are typified by a rounded or blunt inlet followed by a streamline tail, giving a thick or bulbous section in the body with a

relatively less open inlet, a few examples being illustrated at the top of the diagram.

The two types necessarily have characteristic differences at the outlet which belong to their class. Broadly, at low velocities, the efficiency and form of the characteristic appears to be mainly controlled by the inlet portion of the nozzle to the throat, whilst at high velocities both appear to be controlled mainly by the form at the throat and beyond it.

equivalent, for steam, to about 630 and 1460ft. per second respectively. The characteristics obtained in this way for a number of nozzles are shown in Fig. 24. It is noteworthy that in all cases such observations suggest a characteristic always slowly rising with velocity. All but one of the results here shown were obtained with the same bulbous-nozzle types as form the group plotted in Fig. 21 for our S.N.R.C. type of nozzle-tester.

the characteristic variable, because geometrical angle has little significance with these forms, the grouping in Fig. 26 results. I have purposely added the lowest curve, with an efflux-angle of 14·2 deg., because it is known to be a poor nozzle, and the displacement relatively to the 14·6-deg. nozzle immediately above it is the result of this poor form. I did it to remind myself to emphasise that all the other nozzles are good forms for their efflux-angles.

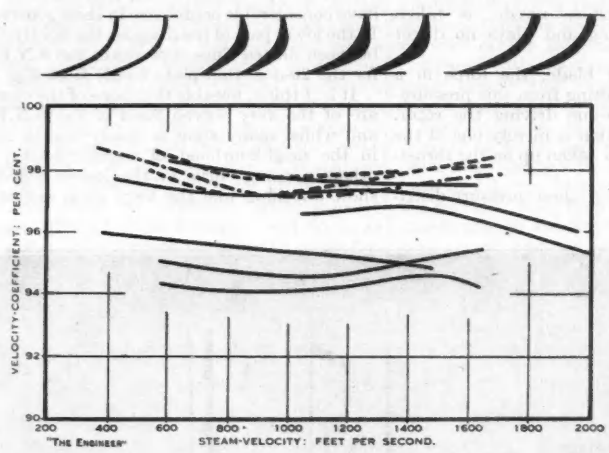


Fig. 20—*M.V. Tests : Thin-Bodied Sharp Open Inlet Types of Nozzles*

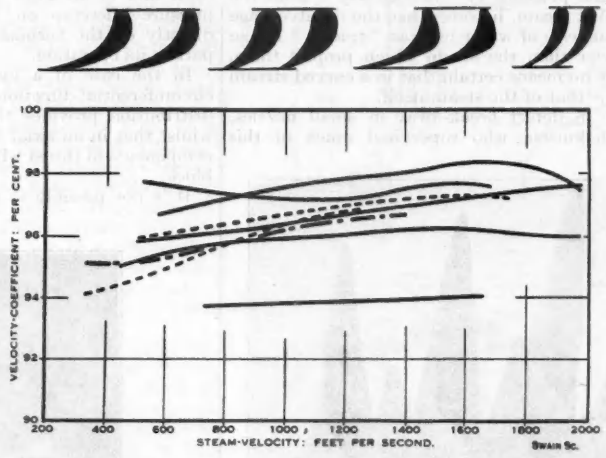


Fig. 21—*M.V. Tests : Thick-Bodied Blunt-Inlet Types of Nozzles*

The profound effect of the exit at the higher velocities is well illustrated by certain of the S.N.R.C. tests re-plotted in Fig. 22, recording the effect of flat and radius chamfer on the 20-deg. thick-plate nozzles. It is significant that these tests suggested, as a result of chamfering, a lowering of the efficiency characteristic at the lower velocities, which I now find scarcely a credible result of improving the outlet.

As two points are scarcely sufficient to establish the shape of a characteristic, I have added one test in which measurements were taken at three velocities, and in order to exhibit it clearly have raised it above the remainder by adding 0·5 per cent. to the actual test velocity-coefficient. It will be noticed that again the three points lie on a straight line slightly sloping upwards with velocity.

It might very naturally be suggested that the difference between the mean angle at the inlet and outlet of the nozzle-vane, or the "camber," should provide a more discriminating criterion for this effect than the angle of efflux of the stream at the outlet. This, however, is contrary to my deductions from our tests. Nozzles having a considerable forward angle at the inlet—giving a big change in camber for the same exit angle—appear to fall into the position dictated by the efflux-angle, and not by the camber. This again illustrates how the part of the nozzle beyond the throat, rather than the early entry part

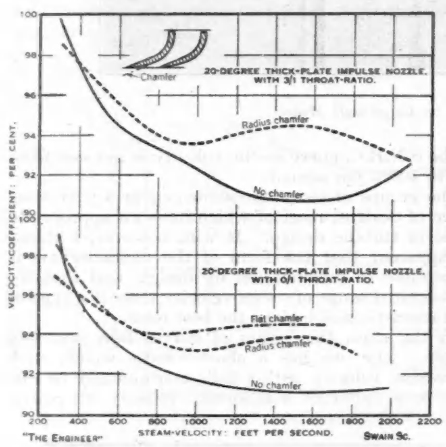


Fig. 22—*S.N.R.C. Tests on the Effect of Chamfer*

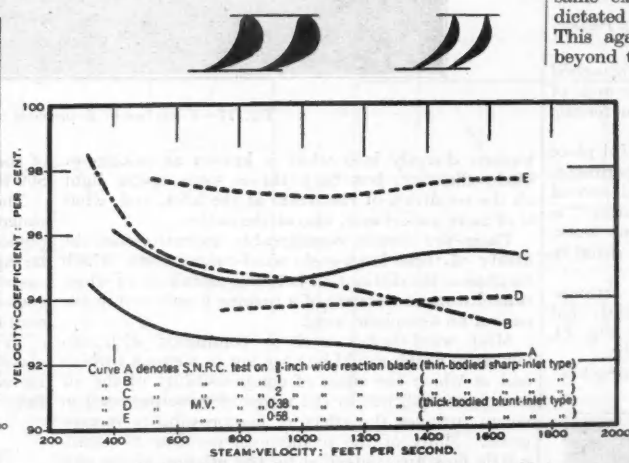

VELOCITY-COEFFICIENT: PER CENT.
STEAM-VELOCITY: FEET PER SECOND.
Curve A denotes S.N.R.C. test on ½-inch wide reaction blade (thin-bodied sharp-inlet type)
B " " " " " 1 " " " " " "
C " " " " " 2 " " " " " "
D " M.V. " " " 0·38 " (thick-bodied blunt-inlet type)
E " " " " " 0·58 " " " " "

Fig. 23—*Tests on Thin- or Thick-Bodied Reaction Blades*

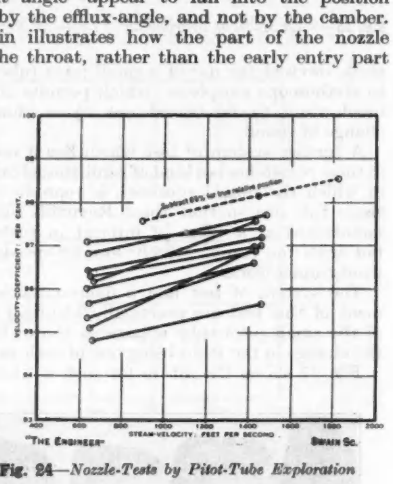


Fig. 24—*Nozzle-Tests by Pitot-Tube Exploration*

Whilst the previous discussion has been limited to tests on impulse nozzles, it is of interest to see how the S.N.R.C. tests on reaction blading compare with later tests that we have made, although with reaction blading of rather different form. On Fig. 23 are re-plotted in full lines the three series of S.N.R.C. tests on reaction blading of various widths, and of a type which falls in the sharp-inlet open-mouth thin-bodied

A further broad discriminating factor between our various results obtained with the S.N.R.C. type of nozzle-tester, and shown in Fig. 19, is to be found in the geometrical angle at the outlet of the nozzle vane-section, or the angle at which the stream of steam leaves the nozzle face.

Thus, in Fig. 25, the curves for certain of the sharp-inlet thin-bodied nozzle-vanes of similar form have

before the throat, seems to be the dominating factor in determining the efficiency characteristic for bulbous vane-sections.

On the curves of Figs. 25 and 26 are plotted isolated test points, which are the velocity-coefficient determination on the same nozzle forms either by one or other of the pitot-tube methods of test. The very close correspondence of the results obtained by these

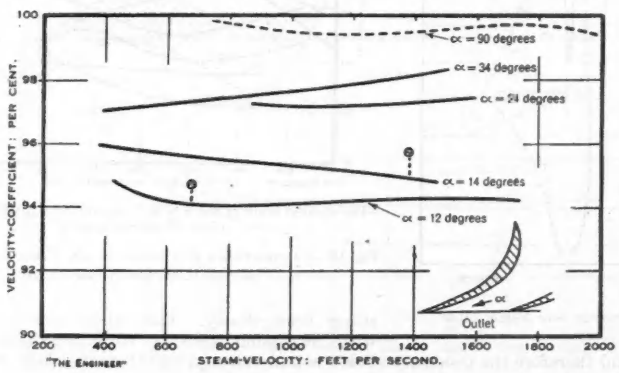


Fig. 25—*Thin-Bodied Sharp-Inlet Impulse-Nozzle Tests of Fig. 19, examined in Relation to Nozzle-Vane Exit Angle, α*

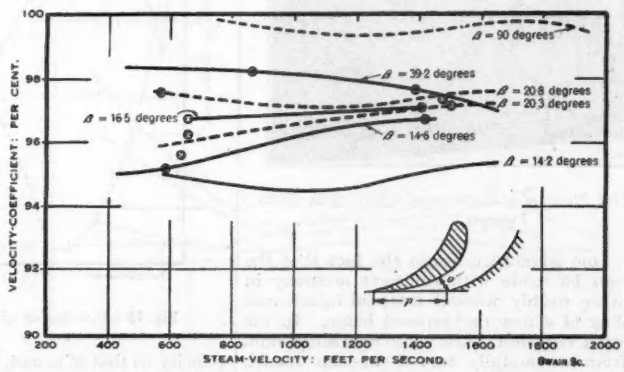


Fig. 26—*Thick-Bodied Blunt-Inlet Impulse-Nozzle Tests of Fig. 19, examined in Relation to the Efflux-Angle at the Outlet, $\sin^{-1} o/p$*

class, together with two tests on our own S.N.R.C.-type nozzle-tester on reaction blading of a rather extreme type of the blunt-inlet thick-bodied class. It is, I think, notable that in general the same difference in type of characteristic is found as occurred in the case of the impulse nozzles.

When nozzle-tests are taken with the small pitot-tube exploration method, we usually limit them to two determinations of efficiency at two velocities

been collected and plotted, with various outlet angles to typify them. To these has been added the test on the S.N.R.C. 1½-in. straight convergent nozzle, for which the outlet angle is 90 deg.

It is, I think, obvious that the outlet angle is a very important factor in the vertical displacement of these curves—that is, in the velocity-coefficient.

Proceeding in the same way for the bulbous-inlet thick-bodied nozzles, but this time with $\sin^{-1} o/p$ as

very different methods confirms, I think, that each method can give very reliable results, and that the curves shown are reasonably accurate.

I am bound to say that in particular cases, even with the greatest care, each method can give unreliable results. It is for this reason that it is not desirable to depend on a single experimental method ; in fact, as the result of painful experience, I hesitate to put much value on the determinations of one method

unless it is confirmed in character by a second.

Whilst on this subject, perhaps I should add that I think it a fair statement to say that results which are confirmed in character by two such methods are later confirmed in character by tests in actual turbines.

I have said "confirmed in character" advisedly, because very frequently if nozzle tests suggest that nozzle "A" is, say, X per cent. better than nozzle "B," tests which later become possible in a turbine very frequently show that, whilst the difference is only, say, $X/2$, or perhaps $2X$, "A" is, in fact, better than "B."

Table II illustrates the kind of variation which we actually find between the different forms of nozzle

TABLE II.

	By nozzle-tester.	By pitot tester.	By turbine test.
Improvement in efficiency of nozzle "A" over nozzle "B": per cent.	0·72	1·84	1·64
Improvement in efficiency of nozzle "C" over nozzle "D": per cent.	3·96	2·04	3·64

experiments and tests in a single-stage turbine.

The degree of agreement here shown is as good as can on an average be expected with nozzle-testing, or, for that matter, with single-stage turbine testing with the degree of accuracy at present attainable in skilled hands.

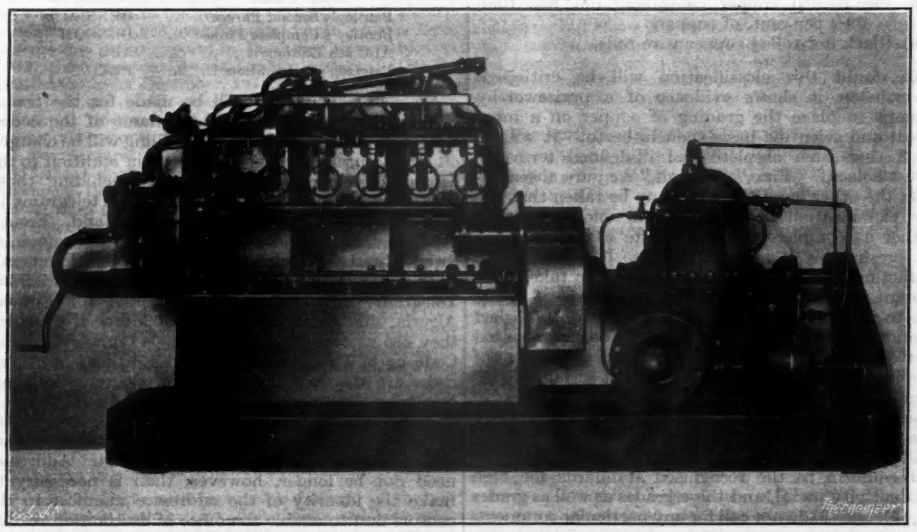
It would be a very simple matter for me to select examples where the results of the different systems of nozzle-tests agree much more closely, or are much more discordant, or even differ from the final turbine test in sign as well as amount, but such results, when they arise, must be regarded with suspicion, and the tests themselves, together with the particular nozzle and blade specimens, as subjects for fresh examination, investigation, and verification.

In spite of these limitations, such experiments are of very real value, because they can be made many months before tools are available and perhaps years before tests can be made in a turbine itself. It is also possible to explore in this way a much larger variety of forms than would be practical in complete turbines. Further, with the most refined technique for testing complete turbine plant, it is quite impossible to detect, with any degree of certainty, the effect of a change in design of nozzles, which may improve efficiency by as much as 1 per cent. in a few stages of the machine, but necessarily by only a small fraction of 1 per cent. for the whole turbine.

(To be continued)

Fire Fighting Pumping Plant

THE accompanying illustration shows a pumping plant for fire fighting and general service recently supplied by the Pulsometer Engineering Company, Ltd., of Reading. The pumping set consists of a Pulsometer HSRB.6 pump driven by a Parsons engine, and is designed to deliver 750 g.p.m. against a total head of 340ft. when running at 1500 r.p.m. The pump is a two-stage horizontally split casing machine with the impellers arranged back to back, to reduce hydraulic thrust. The casing is of cast iron, and the shaft of steel protected by bronze sleeves between the supporting bearings. The impellers are of gunmetal. The rotating unit of the pump is supported in ball and roller bearings. Driven from an extension of the pump shaft by means of a "V" belt is a water ring type exhauster, which is used for priming the pump. The metals and general construction of the exhauster are similar to those used in the main pump. The exhauster runs continuously, but when the pump is primed an automatic valve isolates it from the pump except for the passage of a small quantity of cooling water. The unit is mounted on a steel bedplate of welded construction built up from steel channels and bars. The driving unit made by the Parsons Engineering Company, Ltd., of Southampton, comprises a six cylinder M. type engine having an output of 110 H.P. at 1500 r.p.m. when running on petrol. Starting is effected by hand at the forward end and the plant is provided with a 12-volt electric starter as well. This engine is fitted with high power down-draught carburettors, an impulse driven magneto and a centrifugal water circulating pump. A special floating coupling is used which enables the pump rotor to be lifted vertically when the top half of the casing is removed. The whole plant is mounted on a fabricated steel bed. It is representative of a number of similar plants of various sizes recently produced for A.R.P. and similar service.



FIRE FIGHTING PUMPING PLANT

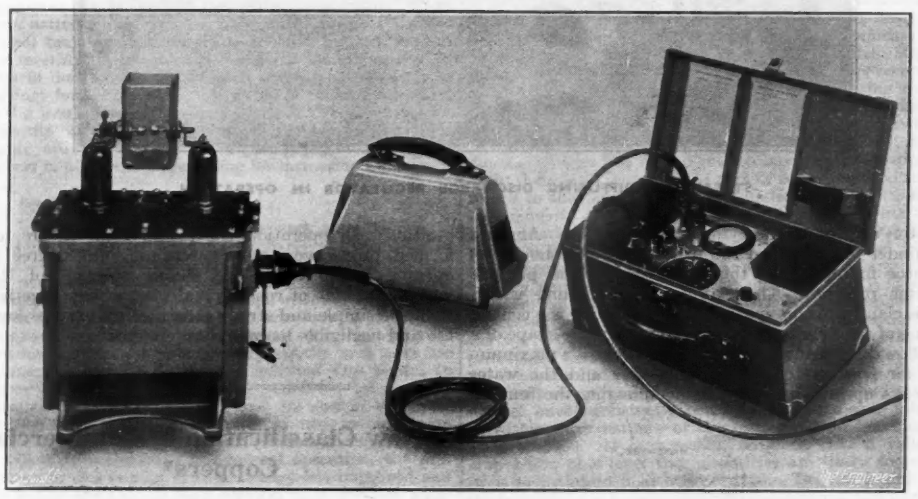
Portable Oil Testing Set

IN order to meet the demand for a light and compact equipment for making periodical tests on site of samples of insulating oil drawn from plant, and also for checking the electric strength of new oil supplies, the British Thomson-Houston Company, Ltd., has introduced the portable oil testing set shown in the accompanying engraving. The set is designed to operate from A.C. supply mains of 200/250 volts, 50 or 60 cycles, and gives voltages from 14 kV up to 50 kV for application to the sample of oil under test. It is easily carried and therefore of particular interest to mining electrical engineers; the transformer package weighs 42 lb. and the control case 25 lb.

To ensure satisfactory results, it is essential for an oil testing set to have, not only the necessary voltage rating, but also sufficient power to effect complete breakdown of the oil sample under test. The equipment illustrated includes a main step-up transformer capable of giving adequate power output, voltage control being obtained by means of tappings on a separate auto-connected control transformer. With this method of control, no distortion of the wave form is introduced; the wave form of the output voltage is a reproduction of that of the supply voltage and should therefore be in accordance with B.S.S. 148. The equipment is claimed to be superior to any type of oil testing equipment depending on an accumulator and an induction coil for its source of power, or one provided with impedance or resistance control, which may give a distorted wave form and tend to limit the power available at the instant of breakdown and lead to indeterminate sparking.

The set is designed to use a gap in accordance with either B.S.S. No. 148 or the American Society for Testing Materials standard D 117–36, and consists of two units, one containing the testing transformer and the other the control and metering equipment. A fully shrouded 2-pin and "scraping earth" plug and socket is provided on the panel of the control case, suitable for the accommodation of a 3-core incoming supply cable, while two insulated terminals and an earth terminal are also available should, for any reason, a temporary direct connection be desired. From the incoming plug or terminals on the control case, the supply is taken through a 2-pole push-button switch to a supply voltage selector switch and tapped auto-transformer, the tappings being brought out to a multiple point control switch. The spring loaded switch is arranged to insert a damping resistance in the primary circuit at the moment of make and break only, in order to limit voltage surges which, otherwise, might seriously upset the readings. A voltmeter, scaled to read the voltage applied to the oil sample, directly in kilovolts, is mounted on the control panel.

From the auto-transformer the supply is taken by a 3-core cable, fitted with fully shrouded 2-pin and "scraping earth" plugs and sockets, to the primary



PORTABLE OIL TESTING SET

winding of the testing transformer which is immersed in a tank filled with insulating compound. The tank top is made of insulating material and carries the H.V. bushings, between which the oil testing cell is mounted during testing. One core of the interconnecting and supply cables is used for bonding together and connecting to earth all metal parts of the transformer tank and control case which are not "alive." This arrangement ensures safety, since all major parts of the apparatus which may come into contact with the operator are at earth potential, except the actual electrodes and oil testing cell. It is, of course, necessary for the earth core of the supply cable to be properly earthed at the supply source. The core and the mid-point of the H.V. winding on the testing transformer are both connected solidly to the tank, as is also the auto-transformer core in the control case.

When used in Great Britain, it is necessary for the transformer part of the equipment to be placed within a "protected area" while testing is in progress, in order to comply with Home Office Regulations. Compartments are provided in the control case for the accommodation, during transport, of the oil testing cell and the connecting cable between the transformer and control case.

Streamline Diffusing Discharge Regulator

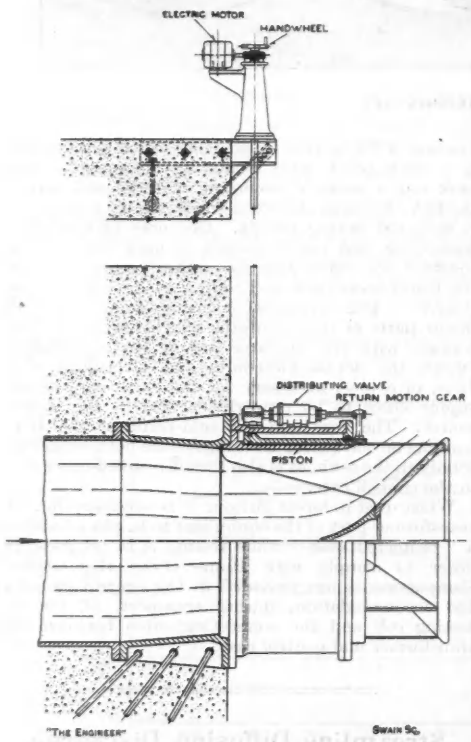
WE illustrate herewith a 7ft. 6in. diameter "English Electric" cylindrical balanced streamline diffusing discharge regulator in operation at the Burrinjuck dam in New South Wales, Australia. The valve was installed in 1937, and was manufactured by the Clyde Engineering Company, Ltd., New South Wales, to the designs of the English Electric Company, Ltd. It has, we are informed, proved so satisfactory in service that a duplicate valve for the second pipeline has recently been ordered from the same makers. The regulator is situated at the end of a 9ft. diameter

pipeline traversing the dam, and passes 3000 cusecs under the highest head of 165·25ft. and 1860 cusecs with the lowest head, which is 63·25ft.

The valve consists of a cylinder bolted to the pipeline flange and integral with a streamline diffusing cone at the centre, the two being joined together by strong ribs. The valve mouth comprises the annular space between the end of the cylinder and the cone, while the degree of opening is regulated by a sleeve or piston sliding on the cylinder and its ribs. Another cylinder fitting round the piston supports the servo-motor for operating the regulator by the pipeline water pressure. The energy of the issuing water, it is claimed, is dissipated very effectively, the central cone of the valve causing a discharge in the shape of a hollow divergent cone. As a result there is a maximum of air friction to absorb the power and the water breaks up into spray, without damaging the foundations. The closing member of the valve being a cylinder is free from distortion and is practically balanced. Consequently there is no danger of jambing and a very large margin of operating power remains in reserve. The channels through the valve are wide and only slightly curved, and hence foreign bodies are readily passed. At all openings the waterway is streamlined, giving a smooth discharge without vibration. The valve, it is stated, is easily installed, all that is necessary being a foundation ring embedded in a concrete block at the end of the pipeline. The same ring is employed to reduce down from the pipeline diameter to the bore of the valve.

The piston is operated by a servo-motor, the pressure water to which is admitted through a distributing valve. A return motion gear makes creeping impossible, for should the piston move the gear will at once act on the distributing valve causing pressure to enter one side of the servo-motor, which will thereupon bring the piston back to the original position. In operation the piston has, we are informed, proved very steady, retaining any degree of opening indefinitely. The sliding surfaces of the valve are made of rustless material, which, together with the simple and strong construction, ensures long life and negligible maintenance charges.

STREAMLINE DIFFUSING DISCHARGE REGULATOR IN OPERATION



SECTION THROUGH DIFFUSING VALVE

A New Classification of Commercial Coppers*

A NATIONAL emergency such as the present is always an occasion for much upheaval and readjustment, but it sometimes provides a long awaited opportunity to revise an existing order of things and to introduce something better to the lasting benefit of all concerned. One such instance is to be found in the copper industry.

Those interested in this industry will notice that in the recently issued Control of Non-Ferrous Metals (No. 5) Order, 1939, a new and perhaps rather unfamiliar classification of commercial copper has been included, which is briefly as follows :—

(1) High conductivity electrolytic copper.
(2) Fire-refined copper sold or intended to be sold as high conductivity copper.
(3) High grade fire-refined copper.
(4) Fire-refined copper of ordinary quality containing not less than 99·7 per cent. of copper.
(5) Fire-refined copper containing not less than 99·2 per cent. of copper.
(6) Black hot-rolled copper wire-rods.

No doubt this classification will be criticised. Nevertheless it shows evidence of a praiseworthy attempt to place the grading of copper on a more logical and scientific basis than hitherto. It will be noted that such obsolete and ill-defined terms as "Best Select," "Fine," "Tough," &c., are absent.

On the other hand the view may be taken that the new classification does not go far enough, and is neither as complete nor as definite as it might be; but presumably it is a compromise based on many conflicting factors which have had to be taken into account to meet the present abnormal state of affairs and to interfere as little as possible with established commercial practice. It will also be appreciated that under the present circumstances sources of supply are necessarily limited, and that certain brands of metal may no longer be available. Little difficulty should be experienced, however, in obtaining suitable substitutes from sources within the Empire.

Copper of grades (1) and (2) in the classification will conform to the recognised standards for high conductivity metal, and these grades as well as grades (4), (5), and (6) do not call for any particular comment.

In the case of grade (3), however, it will be noted that no details are given of what the term "High Grade Fire-Refined Copper" is intended to cover, but it is evident that it is designed to include that large category of first quality fire-refined copper, much of which has in the past originated from Chilean and, more recently, African sources, of which such brands as C.F.R., Braden, M.T.D., B.C.R., and E.R.M. are examples. In nearly all cases the minimum copper content of this grade would be approximately the same as that of the high conductivity grades (*i.e.* about 99·88 per cent.) although of course the metal might not always be suitable for electrical purposes requiring the highest conductivity.

While the new classification is based primarily on conductivity and copper content, and indirectly on impurities, provision has been made to include also certain categories of copper containing very small amounts of specified constituents such as arsenic, cadmium, &c. For the purpose of classification, the specified constituents are to be counted as copper. Thus, for instance, arsenical copper containing over 99·3 per cent. copper and nominally 0·4 per cent. arsenic would be classed not as grade (5) but as either arsenical grade (3) or (4), according to its combined copper and arsenic content.

The need for a more rational classification of copper has long been recognised among progressive producers and users of the metal, and, although the new grading may not be ideal for adoption in all future circumstances without amplification or adjustment, it should be welcomed as the foundation upon which a better and more logical order of things in the copper industry can be established.

* Commented on by the Copper Development Association.

Use of Code in Overseas Telegrams

THE Postmaster-General announces that, under arrangements approved by the censorship authorities, the following codes may now be used in telegrams sent between this country and most places abroad:—Bentley's Second Phrase Code; Bentley's Complete Phrase Code; ABC Code, 6th Edition; Peterson's International Code, 3rd Edition. These four codes have been selected in consultation with representative trade interests; and when some experience has been gained of their use under censorship conditions the admission of other codes will be considered. One code only may be used in any one telegram. Messages in private code, or in any code not mentioned above, will not be accepted. Neither private supplements nor the numerical equivalents of the phrases in the authorised codes are admissible. Groups or series of numbers are not necessarily admissible because they appear in code. Such groups must be accompanied by explanatory words which will make their significance clear to the censors. If the message would not have passed the censors had it been in plain language it will not be passed in code.

Decodes of all code messages must be submitted to the censors. A person handing in a code telegram must furnish at the same time a translation of the text of his message derived from the code book employed. It should be written on a separate sheet of plain paper and clearly marked "Decode." The decode should not be longer than is necessary to make the meaning of the coded text clear to the censors. Prepositions and conjunctions, &c. which are not essential to the meaning, and would not have been included had the telegram been sent in plain language should be excluded.

The name of the code used must be indicated by the sender in the space for service instructions on the telegram form, and the following abbreviations should be used :—

Name of code.	*Abbreviation.*
Bentley's Second Phrase ...	BENSEC
Bentley's Complete Phrase ...	BENCOM
ABC 6th Edition	ABC
Peterson's 3rd Edition	PET

No charge per word will be made for the transmission of the decode or of the name of the code; but a supplementary fee of one shilling will be charged on every outward telegram in code in addition to the normal charge. Certain countries, including those named below, do not at present admit telegrams in code: Argentine, Chile, Egypt, Finland, French Colonies, Iraq, Latvia, Portuguese Colonies, Roumania, Sweden, and Switzerland. For the present Peterson's code may not be used in telegrams to South Africa. Telegrams in code may be accepted for France, Algeria, and the French Zone of Morocco provided they are written in either Bentley's Complete Phrase Code or in Peterson's Code, 3rd Edition; no other codes are at present admissible in telegrams for these countries.

The use of registered abbreviated addresses is still prohibited both in the address and signature of telegrams exchanged with places abroad. Addresses need not be longer, however, than is necessary to make the identity of the addressee manifest to the censors and to enable the office of destination readily to effect delivery without inquiry or reference to directories.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer.

Imports and Exports in 1939.

The summary of the Board of Trade Returns for December, 1939, shows that the total value of the exports of all classes of goods for the year reached £438,806,078 compared with £470,755,320 in 1938, and £521,391,494 in 1937. The imports of all categories of goods amounted to £885,943,676 against £919,508,933 in 1938, and £1,027,824,428 in 1937. The summary shows that the exports of coal for the year were valued at £38,258,793, an increase when compared with 1938 of £852,487. Iron ore and scrap were exported during 1939 to the value of £344,153, a decrease of £250,738. The exports of non-ferrous metalliferous ores and scrap in 1939 reached in value £1,561,031, a decline of £737,084 on the exports of the previous year. The value of iron and steel and manufactures thereof exported last year amounted to £32,844,383 a drop of £8,711,196 compared with the 1938 total. Exports of non-ferrous metals and manufactures thereof were valued at £12,755,159, a rise of £416,063 over the 1938 exports. Cutlery, hardware, implements, and instruments were exported to the value of £8,718,472, a decrease of £309,215 on the 1938 total. The value of electrical goods and apparatus exported was £11,251,664 which was £2,176,741 less than in 1938. The value of machinery exported in 1939 totalled £47,340,118, which showed a heavy decrease of £10,527,447 when compared with the 1938 total. The value of exports of vehicles, including locomotives, ships, and aircraft reached £39,086,192, which was also a drop from the previous year's level to the extent of £5,541,296. During 1939 the imports of non-metalliferous mining and quarry products were valued at £5,306,096, an increase over the 1938 figures of £594,871. Iron ore and scrap were imported to the value of £9,714,936, a decrease of £1,437,191 on the figures for 1938. Imports of non-ferrous metalliferous ores and scrap amounted to £17,928,480, which showed a rise over the previous year's imports of £1,592,560. The value of iron and steel and manufactures thereof imported in 1939 totalled £17,597,629, an increase when compared with the figures for 1938 of £3,095,060, whilst the imports of non-ferrous metals and manufactures thereof were valued at £38,662,140, a decrease over the 1938 total of £2,154,826. The imports of cutlery, hardware, implements, and instruments in 1939 were valued at £5,683,377, showing a decrease of £1,369,592 on the figure for the previous year. Electrical goods and apparatus were imported in 1939 to the value of £2,801,727, a decrease of £303,213 from the 1938 total, whilst machinery imports reached £24,530,881 last year, an increase of £2,693,901 compared with the 1938 figure. Imports of vehicles, including locomotives, ships, and aircraft in 1939 amounted to £5,492,140, showing an increase on the previous year's total of £959,501.

Imports and Exports in December

Owing to the war conditions which prevailed in the last quarter of the year, the figures giving the exports in December showed a tendency to decline, whilst the imports were generally higher in value. The imports of non-metalliferous mining and quarry products and the like in December were valued at £502,513, a rise of £154,879 over the figure for the corresponding month of last year. Iron ore and scrap was imported to the value of £878,285, an increase when compared with December, 1938, of £497,037. The imports of iron and steel and manufactures thereof in December were valued at £1,869,676, an increase over that month last year of £1,120,686, whilst non-ferrous metals and manufactures thereof were imported to the value of £3,903,178, an increase of £610,531 when compared with the figure for December, 1938. The imports of cutlery, hardware, implements, and instruments were valued in December at £292,474, a drop of £256,670 on the figure in December, 1938, whilst electrical goods and apparatus were imported to the extent of £304,354, which was an increase over the previous year of £50,377. Machinery imports also showed an increase at £1,726,182 of £147,113. Vehicles, including locomotives, ships, and aircraft were imported in December to the value of £210,730, a decline of £230,812 on the total for the corresponding month of 1938. Exports of coal in December totalled in value £3,508,118, a rise of £658,241 over the figure for the corresponding month of 1938. Non-metalliferous mining and quarry products and the like were exported to the value of £121,975, which showed an increase of £47,035 over the total for December, 1928. Iron ore and scrap exports in December were valued at £1649, which registered a considerable decrease of £110,714 from the figure for December, 1938. Non-ferrous metalliferous ores and scrap exports totalled £40,175, another substantial decrease of £204,824 compared with the corresponding month last year. Exports of iron and steel and manufactures thereof in December were valued at £2,773,382, a decrease when compared with the figures for December, 1938, of £617,136. There was also a substantial drop of £229,990 in the value of the exports of non-ferrous metals and manufactures thereof, which last December reached £827,940. Cutlery, hardware, implements, and instruments were exported to the value of £883,495 in December, a rise compared with the figure for the same month in 1938 of £145,739. Electrical goods and apparatus were exported to the value of £964,036, this being £164,496 below the value of the goods exported in the corresponding months of 1938. Exports of machinery last December reached £3,653,780, which was a decline of £1,459,595 compared with the figure for December, 1938. Vehicles, including locomotives, ships, and aircraft were exported to the value of £2,812,374, a drop of £1,008,202 from the figure for December, 1938.

The Pig Iron Market

One of the most noticeable features of the pig iron situation is that in spite of the heavy and increasing demand from the consuming industries, no user seems to be held up for want of material. This is largely due to the careful supervision of distribution by the Control. There is, of course, a stringency in more than one department of the pig iron market, and increased supplies of basic iron are urgently needed by the steelworks. Most of the blast furnaces producing this description are hard put to supply their associated works, and there is no surplus from this section of the industry. Furnaces which normally feed the outside market are swamped with orders and are unable to meet the full demand. To some extent the pressure for supplies is due to the shortage of scrap, and it is evident that considerable tonnages of basic iron as well as scrap will have to be imported. The demand for foundry iron is steadily increasing and the principal users are still the engineering foundries, although there is an increasing call from the light castings makers as units in this industry are transferred to work of national importance. Little business is passing in Cleveland foundry iron, since none of this description is now being made, and stocks are practically exhausted. Consumers, therefore, are obliged to rely upon supplies of other kinds and considerable quantities are being moved from the Midlands to users in the North East Coast district. In the Midlands the expansion in the demand from the light castings foundries is more noticeable than in other districts, but there is considerable capacity still to be absorbed upon war work and the founders are anxiously seeking opportunities to secure business of this description. Supplies of high phosphoric iron appear adequate to meet the demand and to leave a small surplus, but stringency is noticeable in the low phosphoric iron market. It is expected that the output of this class of material will shortly be increased; but in the meantime consumers are supplementing their supplies by purchases of hematite. The Lancashire pig iron market is active, and there is a fair demand for foundry qualities; but there are a certain number of foundries which are not fully employed. There is an active request for low phosphoric iron and also for special foundry qualities. The Scottish pig iron makers are meeting an irregular demand for foundry qualities. This is due to the rather slack conditions at the light castings foundries. The production of other descriptions of pig iron is shortly to be increased. The demand for hematite has also been in excess of supplies, and arrangements are being made to augment production. Consumers in all districts are calling for increasing tonnages.

Scotland and the North

Production at the iron and steel works in Scotland is at a high level and probably in excess of that maintained in December. This is partly due to the repairs and renewals to plant which took place over the Christmas holidays. In spite of efforts to cope with the demand, the works are gradually getting into arrears with deliveries. This causes no surprise, as the demand from the important consuming industries is increasing rapidly and users are learning to adopt a philosophic attitude with regard to delivery dates. Re-rollers, have benefitted by a recent distribution of imported semis and are now in a happier position so far as their supplies of raw materials are concerned than for many weeks. With sufficient supplies of billets to maintain a full rate of operation, the production in this section of the industry has improved and the works are able to look forward to a spell of uninterrupted activity. Their order books, however, are congested, and most of them have considerable arrears to overtake, and sufficient business in hand to keep them fully employed for months. The steelworks are in a similar position and are not likely to experience any relief from the pressure which consumers are exercising to secure deliveries. The chief industries requiring supplies of steel are the constructional engineers and the shipyards, both of which have a large amount of Government work in hand. The demand for plates is particularly heavy and the makers are reluctant to accept fresh business unless it is of a very urgent character. The request for joists and sections is equally strong and every ton that is turned out passes into immediate consumption. The sheet works have been fully employed for many months and although they are in a position to accept business to take the place of the A.R.P. contracts they are unable to to fulfil all the demands made upon them. In the Lancashire market consumers are not finding it easy to place new business and have to try out the market thoroughly to obtain anything like delivery required. Most of the constructional engineering firms have long date contracts, but there is a tremendous amount of business of a supplementary character offering to the works. The heavy engineering industry in this district is well employed and the locomotive and tank and boiler makers are absorbing large quantities of plates.

The North East Coast and Yorkshire

Whilst an attempt is being made to investigate the possibility of bringing into operation any idle plant which may be available, it is realised that this may take a little time, and meanwhile existing plant is being worked to the utmost in an endeavour to meet the insistent demand from consumers of all classes. So large a proportion of the users of iron and steel are now employed upon work for the Government that ordinary buyers have little chance of obtaining their requirements, except after long delay. The demand, in fact, from the priority category of consumers seems to be expanding more rapidly even than was anticipated and the steelmakers' order books are becoming congested. It speaks well for the organisation of the industry that notwithstanding the great pressure of demand deliveries to consumers are being made with regularity and there is little complaint of urgent national work being held up. The shipyards on the north-east coast are fully employed and specifications for plates and angles are being received by the works in considerable volume and have a large degree of priority. The constructional engineering industry is extremely busy on important Government contracts absorbing large quantities of joists and sections. Many of these firms booked their steel requirements for six months ahead, and in some cases are getting to the end of their contracts, so that lately there has been a certain amount of new business in the market, which in most cases consumers have found it difficult to place for definite delivery. The re-rollers in this district have recently received fresh supplies of imported billets and sheet bars and are in a better position as regards their raw material than for some time. These works are fully booked and are now in most cases able to operate their plant at capacity, and it is hoped will be able to overtake some of their arrears of deliveries. In the Yorkshire steel market the situation has changed little. There is a very large production of basic billets, but it is still insufficient to meet the demand. The request for acid carbon billets also has grown to such an extent that makers are now in arrears with deliveries. The production of structural steel has reached a high level and works are experiencing continuous pressure from consumers anxious to secure deliveries. The demand for special steels of all kinds has expanded considerably during the past few months and a stringency is noted in the supply of some descriptions.

Copper and Tin

The electrolytic copper market outside Great Britain has developed an easier tone. This is because the American consumers in the latter part of last year covered their forward requirements heavily, and at the moment appear to be overbought. Another reason is that although neutral countries would be prepared to buy in considerable quantities, there are difficulties with regard to shipping and as most neutral governments are watching their exchange position carefully their nationals are discouraged from buying more than is absolutely necessary. As a consequence the volume of buying in the United States has declined. It is understood that an arrangement has been reached by the Governments of Great Britain, France, and Belgium by which larger quantities of copper will be allowed into the latter country in order to meet increased requirements resulting from the re-armament programme. Several neutral countries have been in the market, although not for large quantities, the principal buyers being Sweden, Norway, Italy, and Japan. Russia has been trying to buy metal but apparently there is no desire on the part of American producers to sell to that country, and it is understood the Russian requirements remain unsatisfied. Conditions in the home market have not changed over the week. The principal feature is the steady and heavy demand from the consuming industries. The supplies reaching this country appear adequate for war purposes, and it is said that no restriction arrangements such as are applied to production in peace time will be allowed to operate during the war. Consumers continue to make their purchases principally through merchants, but no arrangement has yet been reached with the Ministry of Supply by which the merchants obtain remuneration. . . . Prices in the tin market have persistently declined and have now fallen to within near distance of the former official maximum price of £230. It is expected, however, that if values drop below this level the authorities are likely to take steps to maintain it at around £230. The fall is due to the fact that it is known that full production is in progress at the smelters, and although this is not yet apparent in the market it must in the course of a few weeks result in increased supplies coming forward. Even now, however, there is sufficient metal available to meet all requirements, particularly as tin is not used to the same extent in war work as other non-ferrous metals. A feature of the market is that the premium on Straits tin is around about £10. Little tin of this description, however, is reaching this country and users seem to be adjusting their practice to the use of tin refined in Great Britain.

Lead and Spelter

The position in this country seems to be fairly satisfactory and whilst consumers engaged upon work of national importance obtain all the metal they require and deliveries are well regulated, firms needing lead for ordinary commercial purposes are finding difficulty in obtaining supplies. Applications for licences are carefully considered by the Control, and it is assumed that there is little surplus metal after the national needs have been met. Generally speaking the consuming trades are well employed: the lead pipe and sheet makers are busy and also the battery makers. Conditions in the paint trade, however, seem less active than might have been expected, and only moderate quantities are moving in that direction. The demand from the building trade also has been much reduced during recent months. Outside Great Britain the market for lead has become somewhat weaker. Empire producers are of course sending their surplus production, after satisfying their home needs, to this country, and other outside makers of whom the chief is Mexico do not find it easy to market their metal. It is understood that Mexican producers are anxious to sell lead in Europe, but there seems little inclination amongst consumers to pay the price demanded, although it is considered by no means excessive. . . . The market for spelter does not present any particular feature of interest In Great Britain the Control seems able to arrange the necessary supplies for firms engaged upon war work but for those employed on ordinary commercial contracts metal is not so readily forthcoming. There seems to be some scarcity of high-grade spelter, but G.O.B. metal is freely obtainable. In the United States the market has become a little easier, but producers are well booked and regard the situation without anxiety. In neutral countries the price of spelter appears to have receded of late, and in Belgium is about £2 above the British official quotation of £25 15s. The Eastern markets which normally receive supplies of hard spelter from Great Britain seem to be having difficulty in filling their requirements, and there has been a considerable amount of inquiry circulated in other producing countries.

French Engineering Notes

(From our own Correspondent in Paris)

Railway Transport

As the military effort of the allies is centred in France, the pressure upon the railways for the transport of men and war material is abnormally heavy and the whole of the rolling stock must be kept in readiness for any emergency. The railways are requisitioned by the military authorities who have priority over them. The National Railway Company has, therefore, to meet the needs of the public as best it can. For public services the company has limitations imposed upon it not only by a reduced quantity of rolling stock, but also by the necessity of economising coal, so that a maximum total of train mileage had to be fixed for passengers and goods. The result of these restrictions was to put in service fewer and heavier trains. It is evident that train loads have reached a limit. At the outset, the company had urged upon the public to travel by rail only when absolutely necessary, but with the greater tolerance now allowed for travel the passenger traffic has increased, partly because motorists use their cars less frequently in consequence of petrol rationing and a higher cost of the fuel. Goods that were formerly transported by road are now transferred to the railway, and it is affirmed that the goods traffic by rail has increased by between 40 and 50 per cent. The National Railway Company is now in a dilemma. It has no surplus supply of rolling stock, for during the past few years a policy of strict economy necessitated by the heavy railway financial deficit deferred the placing of orders for locomotives, wagons, and coaches. Such orders are now being distributed for urgent execution in France and Belgium, but in present circumstances deliveries are not expected to be made at the specified dates, so that the company has to make the fullest use of the available rolling stock for an undefined period. Not only can the National Railway Company utilise a limited quantity of rolling stock for public transport, but it is short of railwaymen, of whom 100,000 have been mobilised. In the interests of national economy the company states that it must make special arrangements for dealing with the goods traffic, and instructions have been given to users to see that goods are loaded and unloaded without loss of time, for which purpose the company is offering further facilities. By speeding up operations for goods transport the available trucks will be able to deal with much more traffic. An increase in the total train mileage for goods may affect the number of trains that can be run for passengers, and while the company hopes to avoid any serious restriction by a re-arrangement of time tables it continues to urge upon the public to travel no more than is absolutely necessary. Since the mobilisation the total passenger train mileage has been increased, particularly during the last two months of the year, to something like two-thirds of the normal.

Three Reforms

January 1st brought into operation three decrees for which industrialists and others had been prepared for some time past. One of them is the 40 per cent. levy on wages for overtime work which was to have been effected at the beginning of November and was postponed for various reasons until the new year. When the legal forty hours' week was extended to meet the needs of an increasing production, the additional hours were regarded as overtime and were paid for at a progressively higher rate, but after the mobilisation this higher pay was suppressed and the hourly wage for 40 hours was continued for as much extra time as the men might have to work up to 60 hours a week. All work was presumed to be for national defence that excluded rates of remuneration above the normal for 40 hours. The Government went further and declared that the men should contribute, out of their overtime pay, to the "solidarity fund" which had been created in aid of necessitous dependents of men who had given up their jobs for active service. Wages earned beyond the 40 hours a week are reduced by 40 per cent., and the amount of this reduction is paid by employers into the Treasury. In addition to this levy all workers of military age have to pay a 15 per cent. armament tax. Wages cannot be increased without Government authority. This policy is governed by the principle that the men, while being required to work as many hours as may be necessary up to the authorised limit, must not profit unduly from armament manufacture any more than employers. The second decree is the obligation imposed on employers to train a number of apprentices in proportion to the total number of workers and employees in any works or factory. This number of apprentices is fixed at 9 per cent., which will be reached progressively with a start of 3 per cent. at the beginning of this year. Apprentices may be trained in individual works, or a number of works in the same industry may combine to create a training school for apprentices in the required proportion to the total number of workers and employees in all the works concerned. The problem of skilled and specialised labour becomes so increasingly urgent of solution that the more essential features of the general plan are being developed as rapidly as possible, so that eventually the whole compulsory apprenticeship system will be completed without undue loss of time. The third event of the new year is that which marks the final date when all road passenger transport companies and owners of fleets of omnibuses and lorries engaged on public work or services must have equipped 10 per cent. of their vehicles to run on suction gas or other home produced fuels. The decree is now of a peremptory character, and any question of convenience or suitability will not be permitted to check the acceleration of a movement of national importance. Advantages offered to owners of vehicles so equipped are the suppression of all taxes until July 1st, 1941, beyond which period the tax for public and private transport will be reduced by one half; the load limit is increased by the weight of the equipment up to 1000 kilos; suction gas vehicles will not be requisitioned during hostilities, and road hauliers are free to transport goods over short and long distances without restrictions at present imposed on other vehicles.

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

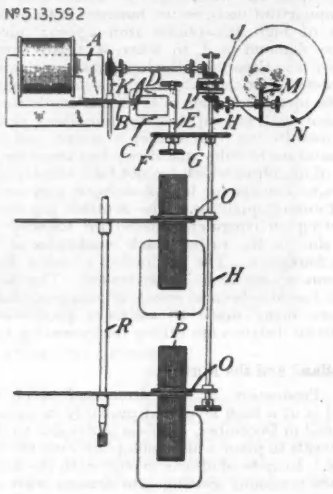
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

MEASURING AND TESTING INSTRUMENTS

513,592. April 6th, 1938.—ELECTRICAL CONTROL APPARATUS RESPONSIVE TO VARIATIONS IN VOLTAGE, Aron Electricity Meter, Ltd., and Edward John Riordan, both of 72a, Salisbury Road, Kilburn, London, N.W.6.

This invention concerns electrical control apparatus responsive to variations in voltage and is concerned with apparatus for use on an alternating current circuit in conjunction with a kVA maximum demand indicator for neutralising the effect on the latter of voltage variations in the said circuit. The variable speed motor employed in this example is a Ferraris motor in which the driving element comprises a shaded pole core A and the driven element is a rotatable aluminium disc B, the necessary braking being provided by a permanent magnet C having its poles or pole pieces D mounted one on each side of the disc. The permanent magnet C is mounted on a spindle E which is parallel with the axis of the aluminium disc B and is connected by gearing F, G to the planet shaft H of a differential or epicyclic gear. The one sun wheel J of this gear is driven,

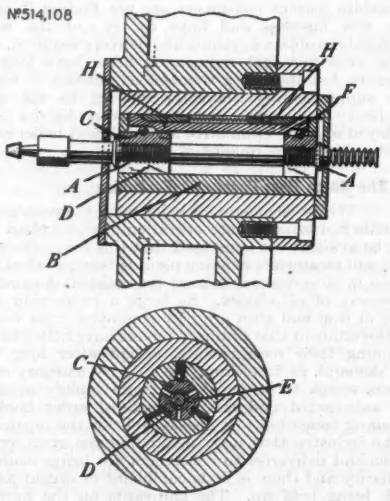


through appropriate gearing, from the spindle K of the Ferraris motor, and the other sun wheel L is driven, also through appropriate gearing M, from a synchronous motor N, for example, one comprising a potential coil and stator with a permanent magnet rotor. At the normal or predetermined voltage, the arrangement is such that the planet shaft H of the differential gear remains stationary with the permanent magnet poles D so located radially of the disc B of the Ferraris motor that there is scope for the adjustment thereof in either direction (outwards or inwards) to produce a variation in the braking which is sufficient to neutralise the effects of any variation in the voltage likely to be encountered. The movements of the planet shaft H of the differential are utilised to neutralise the effects of the variations in voltage upon a kVA maximum demand indicator, the planet shaft H of the differential carrying copper vanes O working in the air gaps between the pole tips of the driving magnets P of the indicator. The movement of the vanes O will correspond to the variation in the voltage and its effect upon the speed of the driven element R of the indicator is proportional to the said voltage variation.—*October 17th*, 1939.

MACHINE TOOLS AND SHOP APPLIANCES

514,108. April 27th, 1938.—HIGH-SPEED SPINDLES AND THEIR BEARINGS, Harry Frederick Atkins, Old Fletton, Peterborough, Huntingdon.

The high-speed spindle and its bearings described are particularly for use in precision grinding where a very high spindle speed is desirable. The spindle has two series of numerous



concentric ribs A having opposed inclined faces which closely engage the correspondingly formed bores of two stationary bearings within a fixed sleeve B held rigidly in a sleeve-carrier bolted to a stationary support. Each of the bearings is of anti-friction metal and constructed of segments C, D, and E, two being fixed to the sleeve by pins, and the third being automatically pressed up to the spindle by a pressure bar F in a gap of the sleeve. This bar is pressed inwardly by wedge-pieces normally separated by a light compression spring between the wedge-pieces. The pressure bar, closely but movably fits at its ends against abutments of the gap, and makes an inward parallel movement to make efficient contact between the grooves and ribs of the bearings and the series of ribs and grooves of the spindle. A ball is disposed between each segment C and the pressure surfaces of the bar. There is therefore an automatic adjustment of both bearings radially and axially. The curvature of the grooves and ribs of the bar segments of each bearing is less than the curvature of the ribs and grooves of the spindle, with the object of reducing frictional contact between bearings and the spindle.—*October 31st*, 1939.

SHIPS AND BOATS

514,242. March 30th, 1939.—IMPROVED SHAFTLESS SCREW PROPELLER, Henry Weissman, 3, Laurel Avenue, Staten Island, New York, United States of America.

Screw propellers which are generally used for marine propulsion comprise a hub secured to a drive shaft and three or four propeller blades projecting outwardly from the hub. One of the difficulties of such propellers is that the outer portions of the blades do most of the work while the inner portions serve primarily as a support or holder. According to the present invention the propelling device comprises a rotatable ring member having a length relatively small with respect to its diameter and having a plurality of blade members attached thereto. The blade members are secured to the inner periphery of the ring member and extend inwardly an amount less than the radius of the ring, leaving an opening extending axially therethrough.—*November 2nd*, 1939.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Institution of Automobile Engineers

Tuesday, Feb. 6th.—Royal Society of Arts, John Street, Adelphi, W.C. 2. "The Instrumental Attack on Automobile Noise," D. B. Foster. 6 p.m.

Institution of Production Engineers

Saturday, Jan. 27th. Yorks. Section. Hotel Metropole, Leeds. "Grinding Wheels," A. Pearson. 2.30 p.m.

Junior Institution of Engineers

To-day, Jan. 26th.—39, Victoria Street, S.W.1. "The Advantages accruing to Forced Circulation Boilers," R. E. Trevithick. 6.30 p.m.

Manchester Association of Engineers

To-day, Jan. 26th.—Engineers' Club, Albert Square, Manchester. "Equipment for Handling Lock Gates, Salvage Work and Heavy Traffic Lifts on the Manchester Ship Canal," W. G. Smith and R. Parker. 7.15 p.m.

Friday, Feb. 9th.—College of Technology, Sackville Street, Manchester. "The Use of Models in Engineering," A. H Gibson. 7.30 p.m.

North-East Coast Institution of Engineers and Shipbuilders

To-day, Jan. 26th. Mining Institute, Newcastle-upon-Tyne. "Propulsion Scale Effect," W. P. A. van Lammeren. 6 p.m.

Friday, Feb. 2nd.—Technical College, Sunderland. "Recent Developments in Shipbuilding and Marine Engineering," W. Muckle. 6.45 p.m.

Royal Institution of Great Britain

To-day, Jan. 26th. 21, Albemarle Street, W.1. "Long Distance Broadcasting," Sir Noel Ashbridge. 5 p.m.

Royal Society of Arts

Wednesday, Jan. 31st.—John Street, Adelphi, W.C.2. "Architecture—1919 to 1939," H. Robertson. 2.30 p.m.

Society of Chemical Industry

To-day, Jan. 26th.—Caxton Hall, Caxton Street, S.W.1. Symposium "Molecular Size and Structure and their Influence on the Properties of Plastics." 6.30 p.m.

Society of Engineers

Tuesday, Feb. 6th.—Royal Empire Society, Northumberland Avenue, W.C.2. Luncheon. 12.45 p.m.

CALENDARS AND DIARIES

ARMCO, Ltd., Thames House, Millbank, S.W.1. Pictorial wall calendar showing past, present, and next months.

HARLAND AND WOLFF, Ltd., Belfast. Wall Calendars.

MATHER AND PLATT, Ltd., Park Works, Manchester. Desk reference pad and diary.

PECKETT AND SONS, Ltd., Bristol. Monthly wall calendar.

RANSOME AND MARLES BEARING COMPANY, Ltd., Newark-on-Trent, Wall Calendar.

FRANCIS SHAW AND CO., Ltd., Corbett Street, Manchester. Wall Calendar.

ROBERT STEPHENSON AND HAWTHORNS, Ltd., Forth Bank Works, Newcastle-upon-Tyne. Wall calendar with daily tear off sheets.

EDWARD WOOD AND CO., Ltd., Ocean Ironworks, Manchester. Monthly wall calendar.

CATALOGUES

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., Manchester.—Publication 7783/1, "Metrovick Electric Welding."

SAMUEL FOX AND CO., Ltd., Stocksbridge Works, Sheffield. A rapid reference folder on "Silver Fox" stainless steels, giving the forms in which they are supplied, properties, machining, welding, and treatment.

CHARLES E. DOUGLAS AND CO., Ltd., 206–8, Cecil Chambers, Strand, London.—Loose leaf catalogue of the "Oilaulic" products of John Mills and Co. (Llanidloes), Ltd., for which the company is the London and export agent.

DANIEL ADAMSON AND CO., LTD., Dukinfield. A new edition of the loose leaf brochure on fusion welded pressure vessels. It describes in detail the various departments in the firm's works dealing with this class of work, and illustrates a number of such jobs carried out. A section of the publication gives detailed rules and regulations of some of the recognised Authorities in this country and abroad.